Navigation Improvement Project
General Design Memorandum

Portsmouth Harbor & Piscataqua River Maine & New Hampshire

NOVEMBER 1985

070

US Army Corps of Engineers
New England Division

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

REPLY TO
ATTENTION OF

NEDED-DE

22 November 1985

SUBJECT: General Design Memorandum Navigation Improvement Project, Portsmouth Harbor and Piscataqua River, Maine and New Hampshire

CDRUSACE (DAEN-ECE-B)
20 MASS. AVE., N.W.
WASH., DC 20314-1000

1. In accordance with ER 1110-2-1150, dated 15 November 1984, submitted herewith for review and approval is the General Design Memorandum for the Navigation Improvement Project at Portsmouth Harbor and Piscataqua River, Maine and New Hampshire.

2. It is recommended that the navigation improvement project for Portsmouth Harbor and the Piscataqua River as submitted in this memorandum be approved as the basis for preparation of contract plans and specifications.

FOR THE COMMANDER:

Enclosure (14 copies)

RICHARD D. REARDON
Chief, Engineering Division

PORTSMOUTH HARBOR AND PISCATAQUA RIVER
MAINE AND NEW HAMPSHIRE

NAVIGATION IMPROVEMENT PROJECT

GENERAL DESIGN MEMORANDUM

DEPARTMENT OF THE ARMY
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SYLLABUS

The New England Division (NED) Corps of Engineers has prepared this General Design Memorandum (GDM) as part of the Continuation of Planning and Engineering (CP&E) work in support of the proposed modifications to the 35-foot deep existing Federal navigation channel in Portsmouth Harbor.

Harbor users and local officials expect Portsmouth Harbor to continue to play a significant role in the economy of the region by handling an ever increasing amount of waterborne commerce. Waterborne commerce in the harbor has increased from 1.8 million tons in 1969 to 3.1 million tons in 1981. The harbor also serves as the home of the Portsmouth Naval Shipyard and the avenue of fuel deliveries to Pease Air Force Base.

Hazardous conditions in the river make it difficult for local users to realize the full potential of the existing navigation project. The harbor is one of the fastest flowing commercial waterways in the Northeast United States. These currents, in combination with sharp bends, narrow lift bridges and inadequate maneuvering areas, produce a condition where harbor users are being constantly stressed in finding ways to accommodate the larger size ships which are becoming more prevalent in the world fleet. Under what is considered to be an unsafe practice, some larger ships in the 40,000 dead weight ton (DWT) range now use the project. The direct impact to users is that the harbor will be unable to remain competitive and that they will not be able to realize savings in waterborne transportation costs associated with larger size ships.

The unsafe conditions in the channel pose a safety hazard for ships using the harbor. With petroleum products representing 80% of the marine commerce in the port, an accident involving a petroleum carrier could result in an oil spill with catastrophic environmental and economic consequences.

The feasibility study, completed in March 1984, considered a wide array of management measures to address the navigation problems existing in the harbor, including: the use of favorable tides, additional tugs, navigation aids, multiport operations, lightering, using other ports, transfer facilities, bridge modification, bridge replacement and alternative channel improvements. These measures in turn were formulated into alternative plans which were evaluated in terms of efficiency, effectiveness, acceptability and completeness as well as economic and environmental response.

The recommended plan of improvement for the project is the National Economic Development (NED) plan and includes the following major features:

a. Creation of a 35-foot deep emergency maneuvering area between the two vertical lift bridges by widening the channel from 600 feet to 1,000 feet.

b. Widening the northern limit of the channel adjacent to Badgers Island by 100 feet.

c. Widening the southern limit of the channel at Goat Island from 400 to 550 feet.

Items a. and b. above have been collectively designated as Area 1 and Item c. as Area 3, both of which are shown on Plate No. 1.

During the Feasibility Study, consideration was also given to widening the turning basin located at the existing project's upstream limit designated as Area 2. However, it was not found to be economically feasible and it was dropped from further consideration.

The improvement project will provide for transportation savings by allowing users to bring in a larger number of vessels in the 40,000 to 45,000 DWT range. This size ship presently has trouble navigating the Portsmouth channel and is becoming more prevalent in the world fleet.

The project first cost is estimated at $17,920,000 representing an average annual cost of $1,661,000. The project would realize an estimated $2,532,700 in annual benefits resulting in net benefits of $871,700 and a benefit to cost ratio of 1.5 to 1.0.

Construction time for the project is estimated at 17 months. The project involves the removal of 320,000 cubic yards of sand and gravels and 193,000 cubic yards of rock. A bucket or clamshell dredge would be used to remove the overburden material. Rock removal would require drilling and blasting. Disposal of the dredged material and rock would be at the Foul Area in Massachusetts Bay.

PORTSMOUTH HARBOR & PISCATAQUA RIVER
MAINE & NEW HAMPSHIRE
NAVIGATION IMPROVEMENT PROJECT
GENERAL DESIGN MEMORANDUM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

APPENDICES

PORTSMOUTH HARBOR & PISCATAQUA RIVER
MAINE & NEW HAMPSHIRE
NAVIGATION IMPROVEMENT PROJECT
GENERAL DESIGN MEMORANDUM

A. PERTINENT DATA

1. Purpose. The Portsmouth Harbor and Piscataqua River navigation improvement study was allocated funds for the Continuation of Planning and Engineering (CP&E) in Fy 83 for the purpose of preparing a General Design Memorandum pending authorization of the project. This report presents a description and design of project features; environmental considerations; cost estimates; design and construction schedule; operation and maintenance; a benefit summary; and an economic analysis for the proposed modifications to the existing 35-foot deep Federal channel at two bend areas and at a maneuvering area between two vertical lift bridges. (See Plate No. 1).

2. Location. Portsmouth Harbor is located at the lower end of the Piscataqua River which is 13 miles long and constitutes a portion of the boundary line between the States of Maine and New Hampshire. The harbor is approximately 45 miles northeast of Boston Harbor, Massachusetts, and 37 miles southwest of Portland Harbor, Maine.

3. Physical Features. The selected plan includes creating a 35-foot deep emergency maneuvering area between the two vertical lift bridges by widening the channel in this area from 600 feet to 1,000 feet; widening by 100 feet, the northern limit of the channel adjacent to Badgers Island (See Area 1 on Plate No. 3); and widening the southern limit of the channel at Goat Island from 400 feet to 550 feet. (See Area 3 on Plate No. 2).

4. Principal Quantities.

Dredging Channel & Maneuvering Area

a.	Ordinary Material	320,000	cubic yards
b.	Ledge Rock	193,000	cubic yards
	TOTAL	513,000	cubic yards

5. Estimated Cost (1 Oct 1985 Price Level)

Channel and Maneuvering Area

Ordinary Material 320,000 c.y. @ $12.40/c.y.	$ 3,968,000
Ledge Rock 193,000 c.y. @ $54.70/c.y.	10,557,100
Contingencies	2,174,900
Subtotal	16,700,000

* Engineering & Design	$ 370,000
* Supervision & Administration	830,000
Total Construction Cost	$17,900,000
Aids to Navigation	20,000
Total Estimated First Cost	$17,920,000

6. Cost Apportionment. **

Federal (USCE) (65%)	11,635,000
(USCG)	20,000
Non-Federal (35%)	6,265,000

7. Economic Analysis.

Annual Benefits	$ 2,532,700
Annual Charges	$ 1,661,000
Benefit-Cost Ratio	1.5 to 1.0

* Excludes CP&E costs incurred prior to 1 October 1985
Includes $30,000 to cover the cost of the monitoring program to assess the effects of blasting on the finfish population.

** The cost sharing is consistent with S.1567, as reported out by the Senate Environment and Public Works Committee on August 1, 1985.

PORTSMOUTH HARBOR & PISCATAQUA RIVER
MAINE & NEW HAMPSHIRE
NAVIGATION IMPROVEMENT PROJECT
GENERAL DESIGN MEMORANDUM

B. INTRODUCTION

1. Project Authorization. The construction and maintenance of this proposed navigation improvement project to the existing 35-foot deep Federal project in Portsmouth Harbor and the Piscataqua River has not been authorized to date. The plan recommended in the April 1983 Feasibility Report as revised in March 1984 provides for the modification of the existing channel at two bend areas and the creation of a 1,000 foot wide by 35 foot deep emergency maneuvering area between the two vertical lift bridges.

2. Recommended Plan. The recommended plan of improvement for the project includes the following major features:

a. Creation of a 35-foot deep emergency maneuvering area between the two vertical lift bridges by widening the channel from 600 feet to 1,000 feet. (See Area 1 on Plate No. 3).

b. Widening the northern limit of the channel adjacent to Badgers Island by 100 feet. (See Area 1 on Plate No. 3).

c. Widening the southern limit of the channel at Goat Island from 400 to 550 feet. (See Area 3 on Plate No. 2).

C. LOCAL COOPERATION

3. General. Construction of the proposed navigation improvement project is recommended provided that, prior to construction, local interests furnish assurances satisfactory to the Secretary of the Army that they will provide the exact amount of non-Federal contributions to be determined by the Chief of Engineers, in accordance with the requirements described below. The State of New Hampshire Port Authority serves as the local sponsor for the proposed navigation improvement project in Portsmouth Harbor and the Piscataqua River.

4. Requirements. Widening of the existing Federal channel in Portsmouth Harbor and the Piscataqua River in accordance with the recommended plan of improvement is subject to the following conditions of local cooperation:

a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for implementation and later maintenance of the project and for aids to navigation, upon the request of the Chief of Engineers including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and later disposal of dredged material and including necessary retaining dikes, bulkheads, and embankments therefor, or the costs of such retaining works;

b. Hold and save the United States free from damages due to implementation and maintenance of the project, not including damages due to the fault or negligence of the United States or its contractors;

c. Provide and maintain without cost to the United States, adequate terminal and transfer facilities open to all on equal terms;

d. Provide and maintain without cost to the United States, adequate depths in berthing areas and local access channels serving the terminals;

e. Accomplish without cost to the United States, all alterations and relocations of transportation facilities (excluding railroads, combined highway and railroad and publicly owned highway bridges and approaches thereto), storm drains, sewer outfalls, utilities and other structures and improvements made necessary by the project;

f. Prohibit the erection of any structures within a distance to be determined by the Chief of Engineers from the bottom edge of the proposed channel and turning basin; and

g. Provide a cash contribution based on the final project cost allocated to any special local benefits derived from dredged material disposal.

In addition, the local sponsor will be required to pay 35% of the first cost of construction which amounts to $6,265,000 based on the current estimated cost of $17,900,000. The first 25%, equal to $4,475,000, is to be paid in cash and the remaining 10%, or $1,790,000 to be repaid over a 30-year period. This cost-sharing is consistent with S.1567, as reported out by the Senate Environment and Public Works Committee on August 1, 1985 which reflects a compromise reached between the current Administration and Congress on the degree to which non-Federal interests should cost-share in the financing of water resource projects.

In a letter dated 6 September 1985, the Honorable John H. Sununu, Governor of New Hampshire, pledged the State's full support for the proposed navigation improvement project for Portsmouth Harbor and the Piscataqua River including the required cost sharing by the non-Federal interests. (See Appendix G).

D. BASIC CONSIDERATIONS

5. Project Location and Description. The Piscataqua River forms a portion of the boundary line between the States of Maine and New Hampshire. Portsmouth Harbor, located at the mouth of the river, is about 45 miles sailing distance northeast of Boston Harbor, Massachusetts, and 37 miles sailing distance southwest of Portland, Maine.

The river is about 13 miles long and has a tortuous channel that winds around sharp bends and over submerged ledges, making navigation hazardous. The head of the existing Federal channel starts with a 35-ft. deep by 850-ft. wide turning basin located approximately 1,700 feet above the Sprague dock in Newington, New Hampshire. From this point, the channel extends downstream for about 6.2 miles to the mouth of Portsmouth Harbor, and has an authorized depth of 35 feet with a width of 400 feet with additional widths at five bend areas and also includes a turning basin 35 feet deep by 950 feet wide just above Boiling Rock. (See Plate No. 1).

6. <u>Tributary Area</u>. The city of Portsmouth and the towns of New Castle and Newington, New Hampshire in Rockingham County, and the towns of Eliot and Kittery, Maine in York County comprise the land areas included in the study area. The city of Portsmouth which has the greatest influence on the port was settled in 1623 and incorporated in 1849. Its primary development has been as a port city, with facilities for both commercial and military vessels located in the harbor. More recently as highways have been built, particularly Route I-95, southern New Hampshire's ties with Massachusetts have been tightened. Portsmouth's many historical sites, its proximity to the ocean, and its growing cultural resources have attracted many visitors. The region has also been successful in attracting light industrial development and service industries, creating a well-balanced economic base. For these reasons, the region has become important as a residential and vacation area.

E. INVESTIGATIONS

7. <u>Previous Investigations</u>. A hydrographic condition survey was conducted in 1977 for use in determining existing project depths, for laying out various channel modifications and for developing quantity estimates for the array of alternative plans considered in the feasibility study.

A seismic refraction exploration program was conducted in December 1977 in the area of the two bends and between the two vertical lift bridges in order to delineate the bedrock contour for use in establishing the amount of rock that would need to be removed during project construction. Seismic velocities indicated the presence of either tills or soft sediments or both overlying bedrock in all these areas. An area of exposed or thinly covered bedrock was indicated in both the bend areas. Since more accurate probe and boring data were obtained later, seismic profiles were not used in determining final quantity estimates.

Surface grab samples were taken in 1977 and 1979. The sediments within the project area were found to contain mostly sands and gravels. Some clayey, sandy gravel mix was found in Area 1. All the samples, consisting mainly of gravel, also contained algae growth and exhibited a marine odor. The algae and odors may be due to the influence of the municipal and industrial discharges along the estuary that keep the nutrient levels sufficiently high enough to stimulate algae growth.

8. <u>Investigations Conducted during CP&E Effort</u>. In the latter part of 1983 and the early part of 1984, an extensive probing and boring program was carried out in the proposed improvement areas between the two vertical lift bridges and at the bend on the northern limit of the channel adjacent to Badgers Island and at the southern limit of the channel at Goat Island. The results of this investigation were used to define the quantity and character of bottom materials to be dredged to construct the proposed improvement project. The Geotechnical Appendix A contains a detailed discussion of the subsurface investigations that were conducted for this study.

A preliminary engineering study was conducted in the early part of 1984 to determine the feasibility and cost of altering the Maine-New Hampshire Interstate bridge to increase the width of the navigation opening from 200' to 300'. The results of this study are contained in the report entitled

"Alteration of Maine-New Hampshire Interstate Bridge Spanning the Piscataqua River, Portsmouth, NH to Kittery, ME.", dated 15 March 1984 and were presented in the March 1984 revision of the feasibility report for the project. The Board of Engineers for Rivers and Harbors (BERH) did not recommend that bridge alterations be included as part of the improvement project.

At the request of the Board of Engineers for Rivers and Harbors, a ship simulation model study was conducted to refine the limits of the emergency maneuvering area being proposed in the area between the two vertical lift bridges. The ship simulation study was carried out by the Computer Aided Operations Research Facility (CAORF), located at the U.S. Maritime Academy in King's Point, New York during the first half of 1985. The Waterways Experiment Station (WES) in Vicksburg, Mississippi collected field current data during September 1984 for input to their mathematical hydrodynamic model to define the current regime in the lower portion of the Piscataqua River. The model results were required input to the ship simulation model study. In addition, personnel from WES provided technical oversight to the simulation study. The executive summary documenting the results of the ship simulation model study is contained in Appendix B and a discussion of the hydrodynamic model study is presented in Appendix C.

A historic-archaelogical field survey was conducted in the proposed improvement areas in the Piscataqua River in the early part of 1984. The results of these field investigations indicated that there are no significant cultural resources in the proposed improvement areas. The results of this investigation are contained in a report entitled "Underwater Archaelogical Testing Portsmouth Harbor, Portsmouth, NH", dated 28 May 1984. In a letter, dated 18 June 1984, the Maine Historic Preservation Officer concurred with the report findings and indicated "that the proposed dredging will have no effect upon any structure or site of historic, architectural, or archaeological significance as defined by the National Historic Preservation Act of 1966."(See Appendix G).

An underwater survey was conducted in early September 1985 in the proposed improvement areas to determine whether or not a viable lobster fishery exists. A discussion of how the survey was conducted and what the preliminary results of the survey show is contained in the section of this report entitled Environmental Analysis and is detailed in Appendix E.

9. Public Participation. Several public workshops were held throughout the course of the feasibility study which was initiated with the issuance of a public notice on 15 November 1976. Due to strong support and interest in the project, local interests organized the Portsmouth Harbor/Piscataqua Safety Improvement Committee. This committee comprised of members from private industry, local and State agencies and harbor users, has played an active role throughout this entire study. Communication and correspondence has also been maintained with the U.S. Fish and Wildlife Service, Concord area office; Environmental Protection Agency; Department of Health and Human Services; National Marine Fisheries Service; State of Maine, Department of Environmental Protection; Resource Planning Division; State of Maine Planning Office; State of New Hampshire, Fish and Game Department and Office of State Planning; and the Greater Portsmouth Chamber of Commerce.

10. Future Investigations. During the course of their review of the feasibility report, the State of Maine expressed a concern for the effects blasting will have on the finfish in the area. As a result of these concerns, an anadromous fish monitoring program will be undertaken during construction to minimize impacts to the anadromous fish populations within the river. Details concerning the monitoring program are contained in paragraph 28 of this report entitled Environmental Monitoring Plan.

F. HYDRODYNAMICS

11. General. The Piscataqua River constitutes one of the fastest flowing tidal waterways of any commercial port in the Northeastern United States. Due to abrupt channel changes, and the strengths of flood and ebb currents, hazardous cross currents and eddies are formed in the main channel passing north and east of Pierces and New Castle Islands. Portsmouth Harbor is the sole deep draft harbor located in the State of New Hampshire. Most of the commodity tonnage shipped through Portsmouth arrives on vessels in the 30-35,000 DWT range with an increasing trend toward the 40-45,000 DWT class. (See Appendices D and F). These latter vessels typically draw 30-37 feet. The hazardous currents, in combination with sharp bends, narrow lift bridges and inadequate maneuvering areas, have produced a condition where harbor users are being constantly stressed to find new ways to accommodate the larger size ships which are becoming more prevalent.

12. Tributary Area. The Piscataqua River is about 13 miles long and begins at the confluence of the Salmon Falls and Cocheco Rivers. These two rivers are navigable for distances of about 1 mile and 2-1/2 miles, respectively. Below the confluence, the Piscataqua flows in a southerly direction for about 4 miles to a point where it receives the discharge of a 12 square-mile tidal basin consisting of Great Bay and its tributary rivers. Within this 4-mile reach, the Piscataqua River has a natural channel about 400 feet wide in which depths vary from 9 to 28 feet, with 9 feet being the controlling depth in the upper half of the channel and 20 feet in the lower half. Below the junction with the Great Bay outlet, the Piscataqua River swings southeasterly for a distance of about 3,000 feet in which the depth of the natural channel is in excess of 40 feet. The head of the existing Federal channel, at the upstream end of this deep channel, is approximately 1,700 feet above the Sprague dock in Newington, New Hampshire. From this point, the Piscataqua extends downstream for about 4-1/2 miles to Portsmouth Harbor, and has a controlling depth of 35 feet generally with a width of 400 feet or greater, including two turning basins. For the lower section of Portsmouth Harbor, channel depths generally are in excess of 50 feet and widths are in excess of 500 feet.

13. Tides. The tidal cycle in Portsmouth Harbor is semidiurnal with two high and two low waters occurring during each lunar day (approximately 24 hours 50 minutes.) The mean range at Portsmouth Harbor is 8.4 feet. The average mean spring range is 9.7 feet.

14. Currents. The average current velocity at peak tide periods in the main channel varies from about 2.6 to 4.0 knots, whereas in the back channels the velocity varies from less than 1 to 2 knots. During September 1984, personnel from the Waterways Experiment Station (WES) collected current data in the lower portion of the Piscataqua River. This information was used as input to a numerical hydrodynamic model to define the current regime in the lower portion

of the channel. Appendix C contains a discussion of the field data collection methodology and the results obtained from the hydrodynamic model.

15. Navigation Hazards. In conjunction with harbor pilots and harbor users, this study has identified two items that pose immediate major hazards to existing deep-draft navigation in the waterway. The first deals with restricted channel widths that pose difficulties in maneuvering, turning and navigating certain bends located along the waterway. In particular, it has been noted that difficulties are encountered in navigating the bends in the vicinity of Henderson Point (Area 3) and at Badgers Island (Area 1) between the two lift bridges.

The second deals with the lack of an adequate emergency maneuvering area downstream of the I-95 bridge for use by deep-draft vessels coming up river to the terminals. Due to the nature of the standard operating procedures used on the waterway, when the vessels are navigating through the project in this reach, the ship is acted upon by a very rapid following current. When travelling around the bends at Henderson Point and Badgers Island, the pilot is unable to stop the vessel with the tugs. This inability is a result of two factors; first, the velocity and direction of the current at the bends, and second, the momentum of the ship itself. The direction of the current restricts the tug's ability to maneuver the ship. Pilots strive to keep the ships in a direction parallel to the streamlines of the current. At each bend, the currents work to turn the ship across the channel. In the vicinity of Henderson Point, there is a deep area which is used by the pilots in times of an emergency to turn a large vessel at the Naval Shipyard. At Badgers Island, however, it is impossible to stop and the ability to turn is limited to the 600-foot wide channel where there is the necessary depth. Although there is additional deep water in this area, the Maine-New Hampshire Interstate bridge restricts its availability. There are a number of emergency situations such as engine failure, rudder malfunction, failure of the bridge's vertical lift mechanism or rapidly deteriorating weather which may require the need to turn. There have been at least two occasions in the past ten years when ship engines have completely stopped and at least three occasions when steering systems have malfunctioned. Fortunately, these situations did not occur in the two critical areas in the channel.

16. Hydrodynamic Model Study. As discussed in earlier sections of this report, a numerical hydrodynamic model study was conducted by WES for the lower portion of the Piscataqua River and Portsmouth Harbor in order to define the currents in this portion of the waterway during periods of peak tidal currents. The results of the model study were then incorporated into the ship simulation model study performed by CAORF at the Maritime Academy in Kings Point, NY. A detailed discussion of this study is contained in Appendix C.

G. GEOLOGY AND SOILS

17. General Geology, Physiography and Topography. The Piscataqua lowlands are characterized by extensive sand plains and terraces with elevations rarely rising above 100 feet. Large quantities of silt, sand and gravel were deposited from glacial outwash to form the present landscape. Additional glacial deposits of sand and gravel, known as eskers, extend into the upland valleys of most of the major tributaries.

The New Hampshire Coastal Area consists of a flat or gently rolling plain. The coastal divide is poorly defined, with maximum elevation usually less than 60 feet. Glacial hills, known as drumlins, are notable exceptions, forming a portion of the coastal divide with 200-foot elevations. The surficial geology of the coastal area consists mainly of unstratified glacial deposits that have been overlaid with marine deposits. Wave and current action have formed the present beaches and sand bars.

18. Soil Conditions. Laboratory tests, consisting of grain size distribution analysis, Atterberg Limits and percent organic content were conducted on several of the soil samples retrieved from the borings taken in the proposed improvement areas. Most of Area 1 was found to contain soft sediments consisting of sands, silts and clays which are amenable to clamshell dredging. Dense tills, some with nested boulders in direct contact with the rock were found to be present. These tills may require alternative dredging methods. The ledge found below this overburden consists primarily of hard metasiltstone and will require drilling and blasting for removal. Area 3 is composed mainly of dense to medium dense overburden materials and ledge rock.

H. PROJECT DESIGN

19. General. The Portsmouth Harbor and Piscataqua River navigation improvement project was designed to provide for the continued safe and efficient transport of deep-draft waterborne commerce within Portsmouth Harbor and the Piscataqua River.

During the feasibility study effort, investigations were made of the immediate and future regional needs for expansion of deep-draft navigational facilities. Numerous measures capable of satisfying existing and future needs were examined and evaluated based on engineering, economic and environmental considerations. The planning effort was coordinated with concerned agencies and the public. The recommended plan in the Feasibility Report provides for channel modifications involving the widening of two bends and the creation of an emergency maneuvering area located between the two vertical lift bridges.

20. Other Plans Investigated. During the course of the feasibility study, several management measures were identified and investigated as possible ways of meeting developmental and environmental quality objectives relative to deep-draft navigation including the following:

a. Utilize favorable tides

b. Utilize additional tugs

c. Multiport operations

d. Lightering operations

e. Navigation aids

f. Utilize other ports

g. Bridge replacement

h. Transfer facility

i. Bridge modification

j. Channel improvements

Of all the measures that were evaluated, the one involving channel improvements was found to be the best in addressing the planning objectives and the regional developmental needs. This finding remains valid.

21. Project Description, The Portsmouth Harbor and Piscataqua River navigation improvement project has been designed in accordance with EM 1110-2-1613, dated 8 April 1983;ER 1110-2-1404, dated 24 September 1981; and from the results of a ship simulation study conducted by the Computer Aided Operations Research Facility (CAORF) of the National Maritime Administration, during the spring and summer of 1985 to determine the adequacy of the proposed channel modifications. The recommended improvement plan involving the modification of two areas designated as Area 1 and 3 is shown on Plates 1, 2, and 3 and described as follows:

a. Create a 35-foot deep emergency maneuvering area between the two vertical lift bridges by widening the channel from 600 to 1,000 feet. (Area 1).

b. Widen by 100 feet, the northern limit of the channel adjacent to Badgers Island. (Area 1).

c. Widen the southern limit of the channel at Goat Island from 400 to 550 feet (Area 3).

22. Continuation of Planning and Engineering (CPE) Effort. CP&E work was initiated in FY83. This effort focused on determining the adequacy of the channel modifications, that were recommended, and refining the dimensions of the emergency maneuvering area, located between the two vertical lift bridges.

No other plans were considered in detail during the CP&E effort outside of the scope of the recommended plan. The results of the ship simulation model study conducted by CAORF showed that the improvement project as proposed does adequately provide for the safe and efficient transit of waterborne commerce in the waterway. Details of the study are contained in Appendix B.

23. Navigation Aids. The Portsmouth Harbor and Piscataqua River navigation improvement project will require the relocation of two navigation aids on the north side of the channel just north of Badgers Island and one on the south side of the channel in the vicinity of Goat Island. In addition, during the course of the ship simulation model study, it was determined that two additional navigation aids would be needed to designate the corners of the northern limit of the new emergency maneuvering area. The Coast Guard will be contacted to get their concurrence with these changes and any other ones that they may deem necessary.

24. Construction Procedure. Due to the nature and scope of the project a bucket or clam shell dredge would be used to remove the overburden material. Rock

removal would require drilling and blasting. The dredged material would be loaded on bottom dump scows and towed to the Foul Area located in Massachusetts Bay and point dumped at a taunt wire buoy. In accordance with a suggestion made by the Environmental Protection Agency, the rock portion of the dredged material will be placed along the perimeter of the disposal site to act as a physical barrier against the movement of the unconsolidated dredged material.

If, prior to construction, a more economically efficient disposal site became available, the opportunity does exist to change the disposal area in order to ensure the project is constructed in the most efficient, environmentally acceptable and cost effective manner possible.

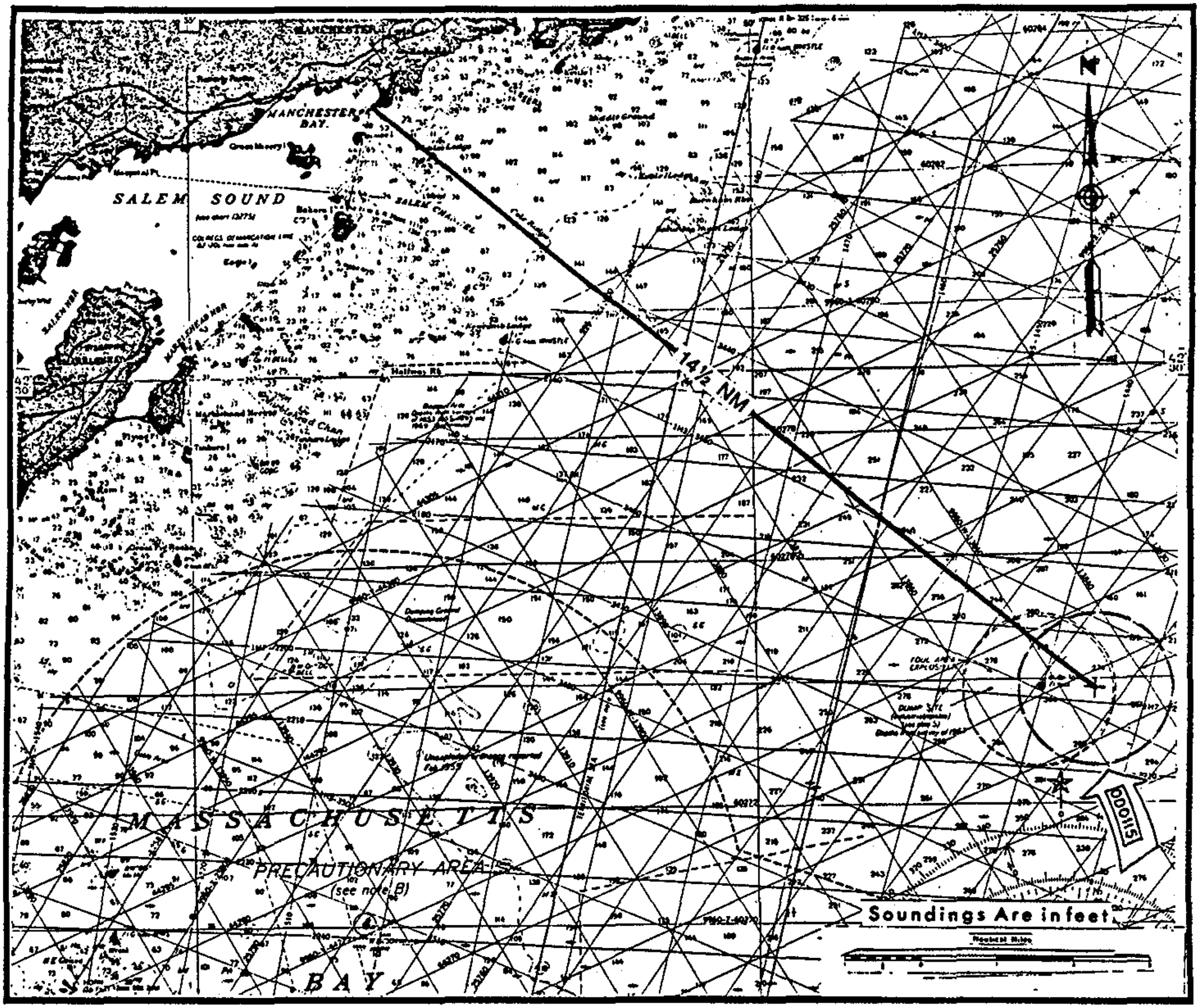
The project will be constructed under one contract and it is estimated that it will take approximately 17 months to complete. Due to the environmentally sensitive nature of Area 3, blasting in this area will be restricted to the months of December thru March. Blasting in Area 1 will also be closely controlled and monitored in order to minimize any adverse effects on the finfish population in the area. As a result of concerns raised by the State of Maine relative to the blasting activity, a monitoring program is being developed and is discussed in the following section and paragraph 28.

25. Environmental Analysis. The environmental assessment contained in the Feasibility Report identified that the proposed blasting and dredging would have an impact on anadromous fish spawning migrations and resident lobster populations. The State of Maine in their Federal Consistency Concurrence and Water Quality Certification (See Appendix G) required that the proposed project areas be surveyed and if a lobster density greater than one lobster per square meter was found, they would be removed; and that a plan should be developed indicating how the effects of blasting on anadromous fish will be minimized.

From 4 - 8 September 1985, a quantifiable diving biological survey was undertaken in the proposed project areas (vicinity of Goat Island and Badgers Island). The survey consisted of two diving biologists swimming thirty (30) randomly located transects recording all lobsters encountered. A total of 4078.224 square meters were covered and 221 lobsters recorded for a density well below one per square meter. The full survey report is contained in Appendix E. A discussion involving the formation of a monitoring team to minimize the effects of blasting on the anadromous fish population is contained in paragraph 28 of this report.

26. Disposal Site. The recommended plan in the Feasibility Report called for disposal of the dredged material at the Foul Area off the coast of Massachusetts. This site presently has an indefinite interim designation status pending the development of an EIS for final designation. The area has a history of being used for the disposal of industrial wastes and dredged material. The currently designated site is available only for the disposal of dredged material that is found to be in compliance with EPA's Ocean Dumping Criteria (Section 102, 40 CFR 227.) The Foul Area is approximately two miles in diameter and is located 22 nautical miles east of Boston in Massachusetts Bay, and 44 miles south, southeast of Portsmouth, with its center at latitude 42° 25.7'N longitude 70° 34' W. The Foul Area is shown on Figure 1.

Physiographically, the site lies within the Stillwagon Basin, an elongate depression over 20 miles in length which trends northwest-southeast. The



FOUL AREA, MASS. BAY

EPA OD0115: Foul Area N.O.S. Chart: 13267
Depth Range: 159 to 304 feet MLW Date: 20 December 1980
Center Coordinates: 42°-25.7'N, 70°-34.0'W
Description: This EPA approved interim site is a circular area with a diameter of 2 nautical miles and center at 42°-25.7'N, 70°-34.0'W. From the center, the Marblehead Tower bears true 282° at 24,300 yards and Bakers Island Horn bears true 300° at 24,300 yards.

FIGURE 1

disposal site is situated in a 300-foot depression which is separated from the Stillwagon Bank area on the east by a 200-foot high slope.

Surveys have identified the natural bottom of the Foul Area as being rather flat and featureless. Also, a variety of disposed objects have been disclosed by bathymetry, including sunken vessels, munitions, concrete casings, metal drums and other debris along with dumped harbor sediments that are scattered throughout the area. A study by the New England Aquarium of an actual dumping operation observed that a significant portion of the discharged material settled rapidly to the bottom.

Bottom currents in the basin and at the Foul Area have been investigated by the New England Aquarium and others. Current monitoring carried out by the New England Aquarium in 1974 recorded mean bottom currents of between 0.13 and 0.16 feet per second, and maximum bottom currents averaging 0.5 feet per second. These values indicate that currents are low and insufficient for any significant spoil dispersal.

27. Operation and Maintenance. The future maintenance dredging of the proposed improvement areas would be carried out at the same time as maintenance on the existing channel. Any additional maintenance dredging due to the improvement project would be minimal. The material would be composed mainly of sands and gravels and would be useable as fill. In general, heavy shoaling is not expected in the improvement areas due to the absence of a nearby source of material and because of the tides and currents which prevent settling out of small grained material.

28. Environmental Monitoring Plan. In order to address the requirements the State of Maine placed on their Federal Consistency Concurrence concerning the need to develop a plan to minimize the blasting impacts on the anadromous fish in the river, NED is in the process of developing a monitoring team.

It is envisioned that this multi-agency monitoring team would consist of biologists from the State of Maine, State of New Hampshire, U.S. Fish and Wildlife Service, Environmental Protection Agency, and Corps of Engineers. This team would determine times of monitoring, and select species to be monitored from the following: *Alosa sapidissima* (shad), *Osmerus mordax* (smelt), *Alosa aestivalis* (blue herring), *Alosa pseudoharengus* (alewives), *Oncorhynchus kisutch* (Silver Salmon), and *Salmo salar* (Atlantic salmon). In addition, this team would recommend measures to reduce potential impacts.

A biological technician would be employed by the monitoring team for the actual monitoring (individual counts per unit time) of the selected species during the predetermined times of blasting activities, to write up field data, and to coordinate his findings with the multi-agency team.

I. COSTS

29. Schedule for Design and Construction. Construction of the project is currently contingent upon authorization of the project by Congress. Assuming project authorization and allocation of construction funds in FY87, construction could start during the 3rd quarter of FY87 and would take approximately 17 months to complete. The project would be constructed under one contract.

30. Navigation Aids. Construction of the improvement project will require the relocation of three existing navigation aids and the addition of at least two new navigation aids to mark the corners of the northern limit of the new emergency maneuvering area. Contact will be made with the Coast Guard to get their concurrence with these changes and any others they deem necessary and to get a final cost estimate for these changes. It is estimated that the two new navigation aids will cost $20,000.

31. Maintenance. The cost of maintenance dredging in the improvement areas is considered to be negligible. In general, heavy shoaling is not expected to occur due to the absence of a nearby source of material and because of the tides and currents in the river which prevent the settling out of fine grained material.

32. Quantities and Cost Estimates. Unit prices used in estimating project construction costs are based on 1 October 1985 price levels. Quantity estimates are based on hydrographic surveys made in 1984 and subsurface explorations undertaken in the fall of 1983. The ordinary overburden material in the improvement areas will be removed by bucket or clamshell dredge while the rock material will require drilling and blasting. The material will be placed in scows and hauled to the Foul Area located about 44 nautical miles from the project site for disposal. It is estimated that about 320,000 cubic yards of ordinary material and 193,000 cubic yards of bedrock will need to be removed for project construction. Dredging quantities are based on inplace measurements and provide for removal to project depths below mean low water, plus a two-foot allowance for overdepth in ordinary material and four-foot in rock. Side slopes for the channel and emergency maneuvering area were estimated to be one vertical to three horizontal for ordinary material and one vertical to one horizontal for rock.

Construction costs include an allowance of 15 percent for contingencies. Costs of engineering and design and of supervision and administration are based on experience, knowledge and evaluation of the project site and comparison with similar projects in the general area. The total first cost of the project is estimated to be $17,920,000. A summary of the current costs for the project is shown in Table 1.

TABLE 1

SUMMARY OF COSTS

(1 October 1985 Price Level)

Acc	Project Features	Estimated Cost
09.	Channel and Maneuvering Area	
	Dredging	
	Ordinary Material 320,000 c.y. @ $12.40/c.y.	$ 3,968,000
	Ledge Rock 193,000 c.y. @ $54.70/c.y.	10,557,100
	Contingencies (15%)	2,174,900
	Total Dredging Cost	$16,700,000
30.	* Engineering and Design	370,000
31.	* Supervision and Administration	830,000
	Total Construction Cost	$17,900,000
	Aids to Navigation	20,000
	Total Estimated First Cost	$17,920,000
	Cost Apportionment **	
	Federal (USCE) (65%)	$11,635,000
	(USCG)	20,000
	Non-Federal (35%)	$ 6,265,000

* Excludes CP&E costs incurred prior to 1 October 1985.
Includes $30,000 to cover the cost of the monitoring program to assess the effects of blasting on the finfish population.

** The cost sharing is consistent with S.1567, as reported out by the Senate Environment and Public Works Committee on August 1, 1985.

The average annual charges for the project, summarized below in Table 2, are based on an assumed economic project life of 50 years and a directed interest rate for Civil Works projects of 8-5/8 percent. Maintenance costs are considered to be negligible and are not shown in the annual charges.

TABLE 2

ANNUAL CHARGES

(TOTAL Federal and Non-Federal) Investment

Construction First Cost	$17,920,000
Interest during Construction	1,021,000
Total Investment	$18,941,000

Annual Charges

Interest and Amortization (.08765)	1,660,000
Maintenance of Aids to Navigation	1,000
Total Annual Charges	$ 1,661,000

33. Comparison of Cost Estimates. A comparison of project cost estimates since completion of the Feasibility Report are summarized in Table 3.

TABLE 3

COMPARISON OF COST ESTIMATES

	Feasibility Report Estimate (March 1984)	Latest Approved Estimate 1 Oct 1985	Current Estimate 1 Oct 1985
Dredging	$19,340,000	$20,790,000	$16,700,000
Engineering & Design	773,600	280,000	370,000
Supervision & Administration	1,166,400	1,130,000	830,000
Aids to Navigation (USCG)	-	-	20,000
	$21,280,000	$22,200,000 1/	$17,920,000 2/

1/ Estimate increased by $920,000. This increase reflects higher price levels ($1,520,000) partially offset by a decrease ($600,000) due to removal of preauthorization costs.

2/ Estimate decreased $4,280,000 based on refinement of quantity of rock to be removed and reduction in contingency factor due to use of more definite final design information developed. This was partially offset by an increase of $20,000 for aids to navigation.

J. BENEFITS

34. General. The benefit analysis is based on a 50-year project life with an 8-5/8% interest rate. The improvement project would provide benefits that are considered general in nature and derived from: (1) projected savings in the cost of transporting commodities on the improved waterway, (2) reduction in risk to shipping, (3) operational savings, and (4) the intangible value provided for national defense and emergencies. It is only possible to assign monetary values to the first three items.

35. Methodology. In determining transportation cost savings, hourly operating costs for various vessel types were used to determine the transportation cost per ton for commodities shipped to Portsmouth. Unit costs were based on round trip distances and include an allowance for tidal delay. Because all deep-draft vessels must dock during slack water at Portsmouth, tidal delay was held constant for all vessel sizes. By allowing for the use of more of the larger petroleum carrying ships that visit the port, channel modifications would result in transportation cost savings. These savings are based on a comparison of transportation costs without the project and transportation costs with the project. Transportation cost savings were computed for petroleum vessels transiting the main channel and emergency maneuvering area. Incidental transportation savings were also computed for ships visiting the Port Authority facilities and the salt terminal. Large salt ships can currently only be turned if light-loaded. The emergency maneuvering area will permit fully loaded salt ships to be turned safely, thus realizing cost/ton savings from the use of the larger vessels already calling at Portsmouth.

Benefits attributable to a reduction of risk to shipping were derived from a risk analysis. If given a choice, a shipper will not move to a larger sized vessel if the additional risk of using that vessel exceeds the transportation savings. If a shipper is to maximize savings, he will use larger and larger vessels until a size is reached at which the additional risk just equals the additional transportation savings. For the with project condition, an analysis was made to determine to what degree risk would be reduced by the proposed improvements to the harbor. Since the risk being measured is the potential losses perceived by shippers, it is assumed that the source of this risk lies in Portsmouth Harbor itself. In essence, the decision of which ships are to be utilized is based on harbor characteristics at Portsmouth Harbor. Given the high value of the vessels and cargo at Portsmouth Harbor and the extremely high potential clean-up cost for an accident, apart from the potential for loss of life and devastating environmental impacts, the prevention of even one bad mishap would be significantly beneficial. The risk analysis was applied to vessels carrying petroleum products, salt and scrap iron.

Incidental operational savings are expected to also accrue to the proposed emergency maneuvering area. The larger area will mean that the large salt vessels and scrap iron vessels can be turned in less time (a savings), which in turn would mean less time in port (a savings), and that these vessels can be turned at any time during the tide cycle whereas now this can only be done at high tide (a savings, i.e. less time in port). A summary of the estimated annual benefits is shown in Table 4. Details of the economic analysis that was performed for the project is shown in Appendix D.

TABLE 4

SUMMARY OF ANNUAL BENEFITS ($1000)

1. Transportation Cost Savings		
Channel Modifications and Emergency Maneuvering Area		
	Petroleum	$ 1,830.9
	Salt	47.9
2. Operational Savings		
	Emergency Maneuvering Area (Salt and Scrap Iron Vessels)	48.0
3. Reduction in Risk		
	Petroleum	499.4
	Dry Bulk (Salt and Scrap Iron)	106.5
	TOTAL BENEFITS	$ 2,532.7

36. Summary of Project Economics. In order for a project to be considered economically justified, it must have a benefit-to-cost ratio of one to one or greater. A comparison of the evaluated annual benefits of $2,532,700 and the annual charges of $1,661,000 for this project results in a benefit/cost ratio of 1.5 to 1.0.

K. STATEMENT OF FINDINGS

37. General. As Division Engineer of the New England Division, I have reviewed and evaluated in light of the overall public interest, all pertinent data concerning construction of the proposed Federal Navigation Improvement Project for Portsmouth Harbor and the Piscataqua River, Maine and New Hampshire. Elements considered in this review included engineering feasibility, environmental impacts, stated views of other interested agencies and the concerned public, and socio-economic factors associated with the various alternatives that were considered to provide for the continued safe and efficient transit of deep-draft waterborne commerce in Portsmouth Harbor and the Piscataqua River.

All aspects and possible consequences of alternative measures have been studied in detail and are discussed in length in the Feasibility Report that was prepared for this project. In the analysis which I have made, I have reaffirmed the conclusions of the Feasibility Report and find no alternative plan or combination of alternative plans that would fulfill the deep-draft navigation needs in the study area to the same extent as the proposed plan that has been discussed in this report. The proposed plan has been determined to be the NED plan for this project. In summary, there are substantial benefits to be derived from ensuring the continued safe and efficient transit of deep-draft waterborne commerce in Portsmouth Harbor and the Piscataqua River and it can be accomplished in a cost effective manner.

I note that the proposed improvement will cause some disruption to the environment during the dredging, blasting and disposal operations due to temporary increase in turbidity and noise level, temporary decrease in dissolved oxygen, and the potential adverse impact on the shellfish and finfish resources in the immediate improvement area. However, due to the significant benefits to be derived from the proposed improvements, I conclude that these adverse effects would be more than offset by the improvement it would provide to both the local and National Economic Development.

L. CONCLUSIONS

38. General. I find that the proposed project as developed in this design memorandum is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objective; that wherever adverse effects are found to be involved, they cannot be avoided by following reasonable alternative courses of action and still achieve the Congressionally specified purposes; and that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations. The recommended plan is consistent with national policy, statutes and administrative directives and, on the whole, the total public interest should be best served by the implementation of the recommended plan.

M. RECOMMENDATIONS

39. Recommendations. I recommend that the existing project for deep-draft navigation at Portsmouth Harbor and the Piscataqua River in Maine and New Hampshire, be modified in accordance with the improvement plan described herein. It is further recommended that this Design Memorandum be approved as the basis for preparation of contract plans and specifications for the Portsmouth Harbor and Piscataqua River Navigation Improvement Project.

These recommendations are made provided that the exact amount of non-Federal contributions shall be determined by the Chief of Engineers and agreed to by non-Federal interests prior to project implementation, in accordance with the items of local cooperation as defined in paragraph 4 of this report.

Thomas A. Rhen

THOMAS A. RHEN
Colonel, Corps of Engineers
Division Engineer

14 NOV 85
DATE

CORPS OF ENGINEERS U. S. ARMY

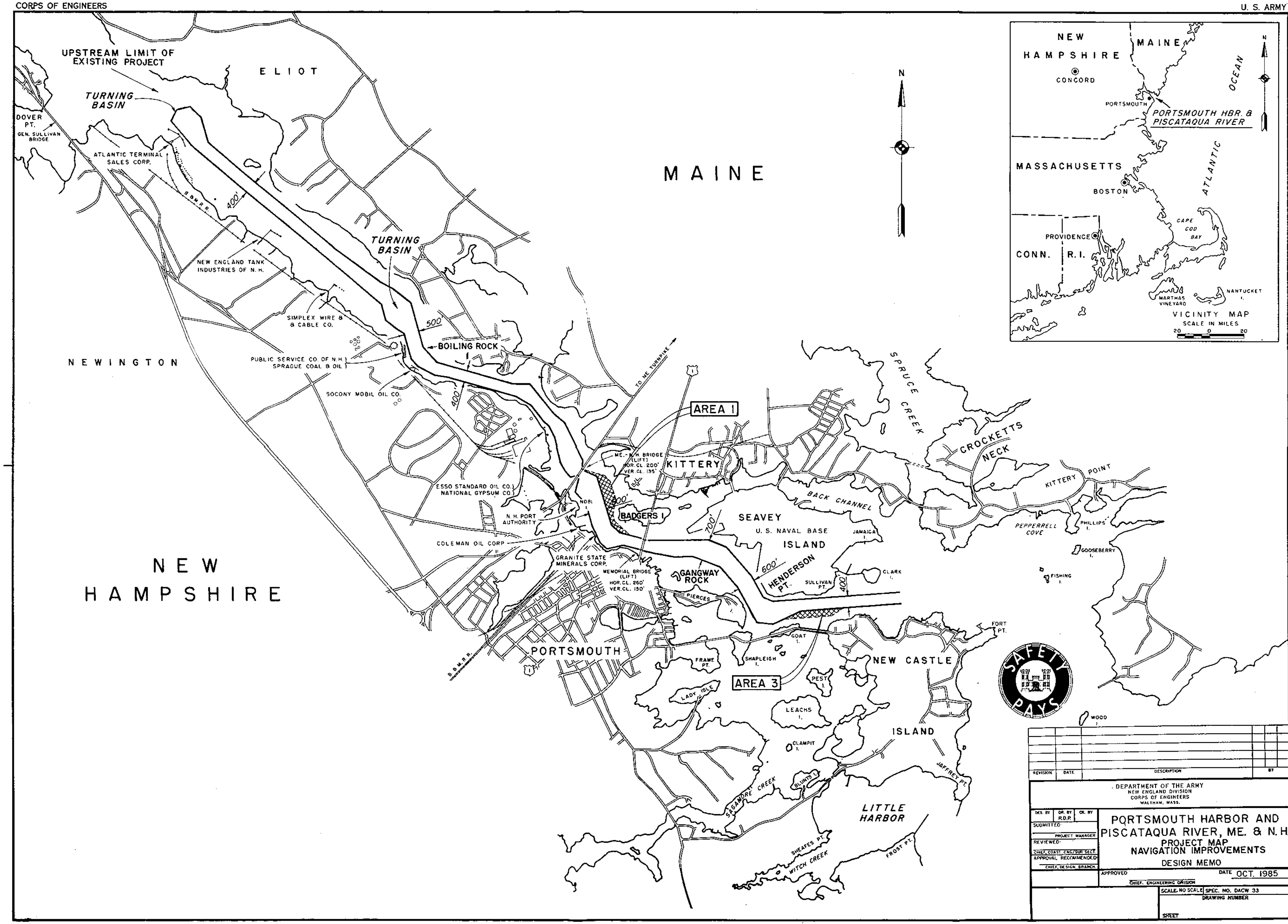
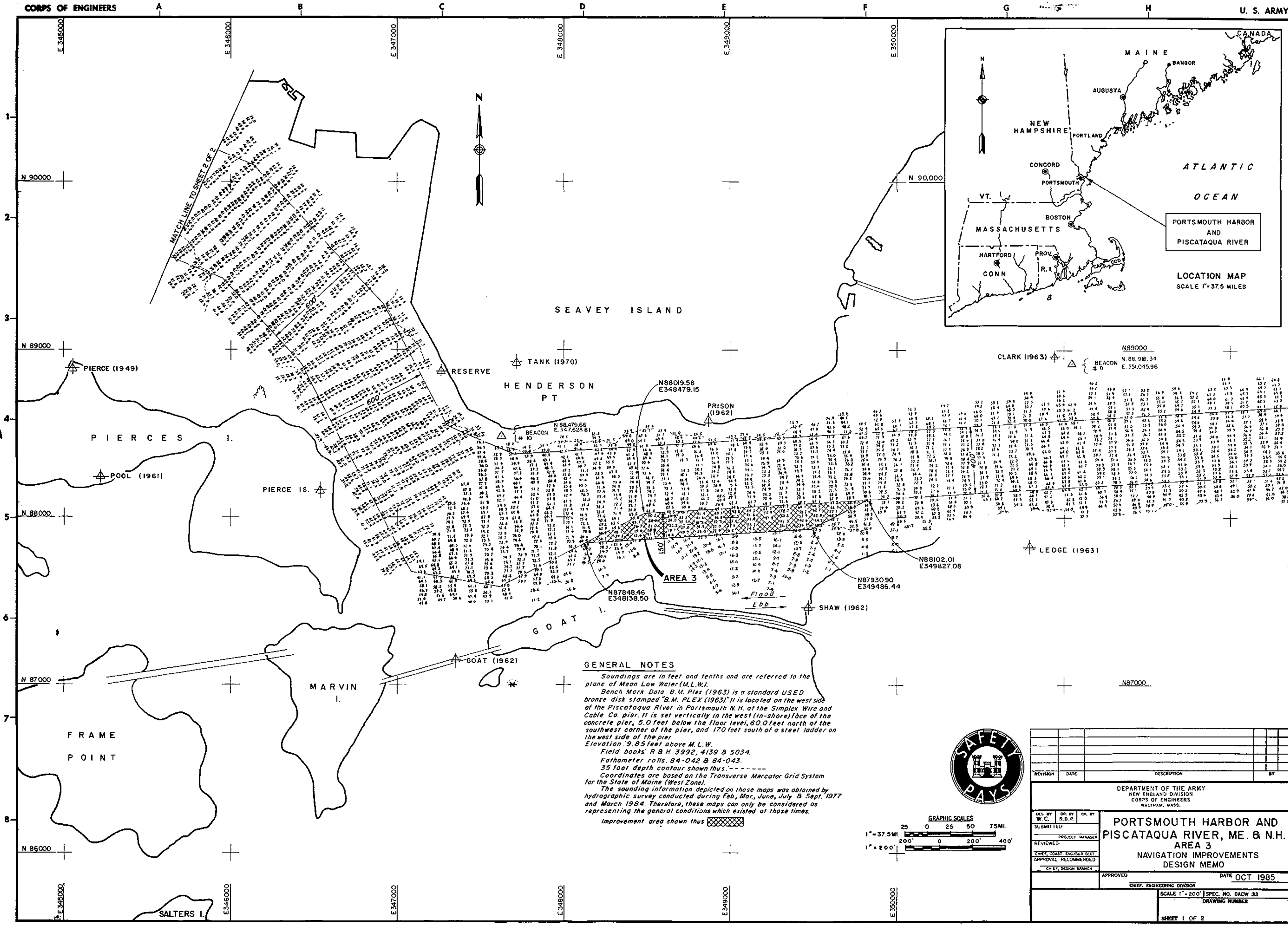


PLATE NO. 1



GENERAL NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water (M.L.W.).

Bench Mark Data B.M. Plex (1963) is a standard USED bronze disk stamped "B.M. PLEX (1963)." It is located on the west side of the Piscataqua River in Portsmouth N.H. at the Simplex Wire and Cable Co. pier. It is set vertically in the west (in-shore) face of the concrete pier, 5.0 feet below the floor level, 60.0 feet north of the southwest corner of the pier, and 17.0 feet south of a steel ladder on the west side of the pier.
Elevation: 9.85 feet above M.L.W.

Field books: R & H 3992, 4139 & 5034.

Fathometer rolls: 84-042 & 84-043.

35 foot depth contour shown thus: - - - - - - -

Coordinates are based on the Transverse Mercator Grid System for the State of Maine (West Zone).

The sounding information depicted on these maps was obtained by hydrographic survey conducted during Feb., Mar., June, July & Sept. 1977 and March 1984. Therefore, these maps can only be considered as representing the general conditions which existed at those times.

Improvement area shown thus

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY W.C. | DR. BY R.D.P. | CK. BY

SUBMITTED: PROJECT MANAGER
REVIEWED: CHIEF, COAST. ENG/SUR SECT.
APPROVAL RECOMMENDED: CHIEF, DESIGN BRANCH

PORTSMOUTH HARBOR AND PISCATAQUA RIVER, ME. & N.H.
AREA 3
NAVIGATION IMPROVEMENTS DESIGN MEMO

APPROVED: CHIEF, ENGINEERING DIVISION   DATE OCT 1985

SCALE 1"=200' | SPEC. NO. DACW 33
DRAWING NUMBER
SHEET 1 OF 2

PLATE NO. 2

CORPS OF ENGINEERS U. S. ARMY

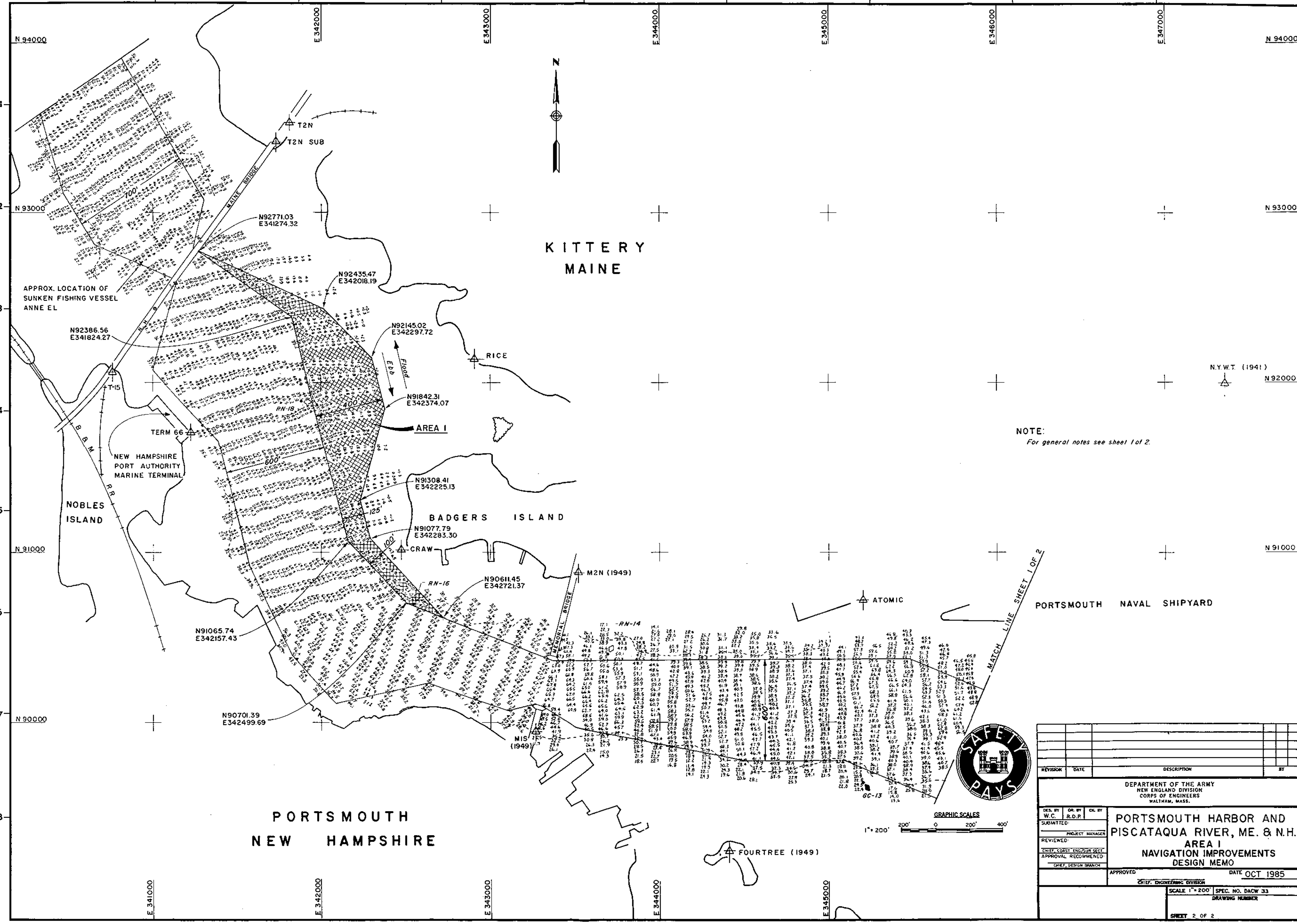


PLATE NO. 3

APPENDIX A

GEOTECHNICAL CONSIDERATIONS

PORTSMOUTH HARBOR GDM
APPENDIX A
GEOTECHNICAL CONSIDERATIONS

TABLE OF CONTENTS

LIST OF PLATES

A. GENERAL

This appendix presents the results of engineering investigations accomplished to define the quantity and character of bottom materials to be dredged for the proposed Portsmouth Harbor/Piscataqua River Navigation Improvement Project. A description of the proposed improvements to the two areas, designated Area 1 and Area 3, is contained in the main report.

B. TOPOGRAPHY

The project is located in the coastal lowlands section of the New England region. This section forms a broad northeast-trending belt from south of the Rhode Island coast, north and northeast to Houlton, Maine. This belt is a low undulating surface which rises gently to the northwest and varies in width from about 30 to 60 miles. Elevations are less than 100 feet NGVD in the vicinity of the project area. The natural channel of the Piscataqua River downstream of the I-95 bridge has some depths over 70 feet, but also has bedrock shoals, the most extensive of which are off of Badger's and Seavey Islands.

C. GEOLOGY

1. Bedrock. Extending from the coast northwestward to just south of Rochester, New Hampshire, is a belt of Paleozoic sediments intruded by and interbedded with igneous rock masses which were folded and metamorphosed into a northeast-southwest axial belt of phyllites, slates, quartzite schist, gneiss and granitic rocks. Rock in Area 1 is mapped as the Kittery Formation, an impure quartzite interbedded with slate, phyllite, or fine grained schist. Outcrops of the quartzitic portion of the formation often show numerous sets of joints and incipient fractures which produce distinctive, highly irregular and angular fragments as the rock disintegrates.

The rock in Area 3 is mapped as the Rye Formation, the oldest of the dimentary units exposed in the Seacoast Region of New Hampshire. It is comprised of two subdivisions, a lower metasedimentary member and an upper metavolcanic member. Area 3 is in the metavolcanic member which is mainly dark schists, gneisses and amphibolites. In outcrops the foliations in these rocks dip steeply to the northwest.

2. Surficial. The overburden in the river basin consists of various deposits and types of material characteristic of glaciation and marine submergence that has occurred in this region. Tills directly deposited by glacial ice and consisting of unstratified well graded sediments blanket most of the irregular bedrock surface. Drumlins are common. As the glaciers receded northward, meltwaters carried silts, sands and gravels southward and eastward to form extensive outwash deposits. During glacial times sea level was higher relative to the land and glacial debris discharged into the sea. Silts and clays were deposited in the deeper water. Marine silts and clays are now found in the lowlands up to an elevation of 200 feet above sea level. The post glacial uplift of the land forced withdrawal of the sea to the present coastline and stream erosion has been actively downcutting through the various glacial and marine deposits. Swift tidal currents have scoured portions of the Piscataqua River channel to bedrock.

D. SUBSURFACE INVESTIGATIONS.

1. General. Subsurface explorations undertaken during this study effort to define existing riverbed conditions included a machine probe and test boring program undertaken in the fall of 1983, and a seismic refraction survey conducted in December 1977. The results of these explorations are discussed below.

2. Machine Probes. A machine probing program was carried out in September and October 1983 using two barge mounted rigs and a 300-pound hammer falling 18 inches on AW size (1.75" dia) rods. Probing locations were established on a 50-foot square grid pattern at both Areas 1 and 3, the lay-outs of which are shown on Plates 1-A and 2-A. A total of 272 probes were performed in Area 1 and 86 in Area 3. The probes were advanced to approximately elevation -40 feet MLW, or to refusal, whichever came first. Sixty percent of the probes in Area 1 encountered refusal at elevations above the project design elevation of -35 feet MLW, as did 50 percent in Area 3. The probe data has been tabulated on Plates 1-A and 2-A and includes ground elevations, refusal elevations, total probe depth, and maximum, minimum and average blow counts recorded for each probe. The probes encountered a full range of resistance, with top materials yielding to the weight of the hammer (WOH) and dense materials requiring up to 124 blows per foot of penetration. Seventeen of the probes in Area 1 and six in Area 3 encountered refusal at the surface.

3. Test Boring Program. A boring program was also undertaken in the same areas to supplement the probing program. Eleven borings were drilled, eight in Area 1 and three in Area 3. Continuous drive sampling was utilized to bedrock whereupon bedrock was cored to about elevation -40 feet MLW. Graphic logs showing boring results are displayed on Plates 2-A and 3-A.

In Area 1, six of the eight boreholes encountered rock. Of these, the average depth of overburden was 18.9 feet, with the rock surface encountered at an average elevation of -28 feet MLW. The overburden primarily consists of sandy silts (ML) and clays (CL) overlying silty sands (SM, SP-SM) resting on the bedrock surface. Exceptions to this profile occurred in borings FD-C and FD-F where a 10-15 foot layer of clay was found below silty sands.

In Area 3, two of the three boreholes encountered rock. In boring FD-1 bedrock was encountered at the surface at elevation -13.0 feet MLW. Boring FD-J encountered bedrock at elevation -35.25 feet MLW, under 5 feet of very soft clay (CL), 5 feet of medium dense silty sand (SM) and 4 feet of nestled cobbles and boulders. Boring FD-K encountered medium dense to dense silty and gravelly sands (SP, SP-SM) from the surface at elevation -22.8 feet MLW to the bottom of the borehole at -40.8 feet MLW.

4. Seismic Survey. A seismic refraction exploration program was conducted in December 1977. A total of 13,615 linear feet of seismic lines generated 12 profiles, 9 in Area 1, and 3 in Area 3. A 12-element hydrophone array with 20-foot spacing between hydrophones was used along with an energy source consisting of small explosive charges detonated on the bottom at irregular intervals. A total of 176 shot points were used.

Seismic velocities indicated the presence of either tills or soft sediments or both overlying bedrock in both Area 1 and 3. An area of exposed or thinly covered bedrock was indicated just off of Badger's Island in Area 1 and over most of Area 3. Since more accurate probe and boring data were obtained later, seismic profiles were not used in final quantity and material estimates.

5. Laboratory Tests. Laboratory tests, consisting of grain size distribution analysis, Atterberg Limits and percent organic content were conducted on several of the soil samples retrieved. The results of these tests are tabulated on Plate 4-A.

E. EXCAVATION CONDITIONS AND QUANTITIES

1. Excavation Conditions. In most of Area 1, there are soft sediments consisting of sands, silts and clays which are amenable to clamshell dredge excavation. Also present are dense tills, some with nested boulders in direct contact with the rock. They are often overlain by soft sediments. The tills may require alternative excavation methods. Ledge consisting primarily of hard metasiltstone will require blasting.

Excavation conditions in Area 3 will be more difficult because of the higher proportion of rock in the excavation quantities. Also, the dense to medium dense overburden materials may require greater effort than clamshell excavation.

2. Quantities. Excavation quantities are based on dredging to elevation -37 feet MLW in overburden materials and to elevation -39 feet MLW in rock. These elevations represent a 2-foot allowable overdepth in soft bottom sediments and a 4-foot allowable overdepth in rock. Side slopes are assumed to be 1 vertical on 3 horizontal for the overburden material and 1 vertical on 1 horizontal for rock. Based on the subsurface explorations conducted, it is estimated that a total of 513,000 cubic yards of material must be excavated to construct the proposed improvement project. Table 1 presents a breakdown of this quantity by area.

TABLE 1

ESTIMATED EXCAVATION QUANTITIES

CUBIC YARDS

Area 1	Overburden	Bedrock
Project Depth	289,000 cyds.	128,000 cyds.
Allowable Overdepth	11,000 cyds.	40,000 cyds.
Total	300,000 cyds.	168,000 cyds

Area 3	Overburden	Bedrock
Project Depth	17,000 cyds.	15,000 cyds.
Allowable Overdepth	3,000 cyds.	10,000 cyds.
Total	20,000 cyds.	25,000 cyds

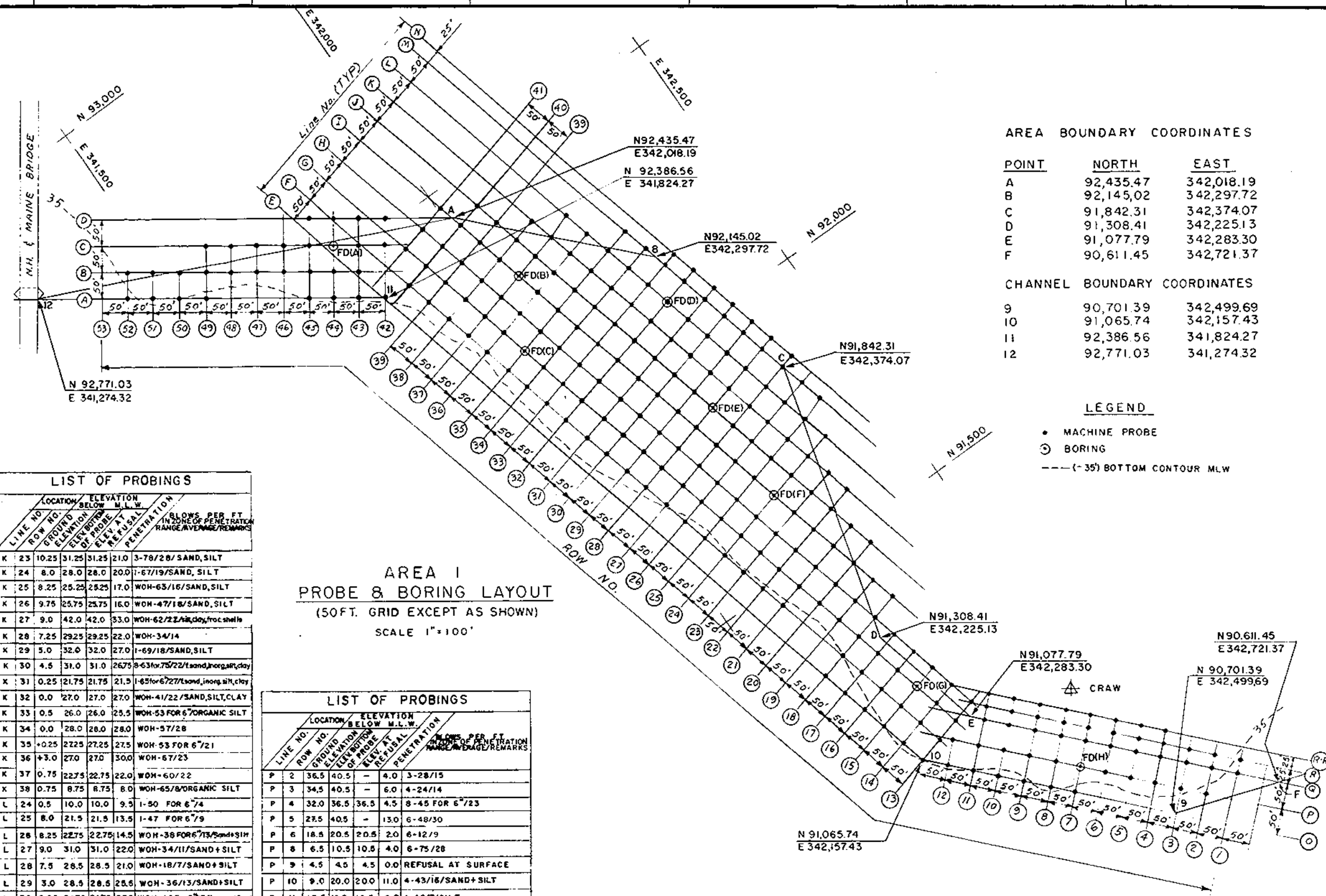
GRAND TOTAL:	320,000 cyds.	193,000 cyds

LIST OF PROBINGS

LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
		LOCATION	ELEVATION BELOW M.L.W.			
A	42	39.25	40.25		1.0	WOH
A	43	40.0	-		-	NOT PROBED
A	44	42.5	44.5		2.0	WOH-3
A	45	41.7	47.7		6.0	WOH-25/11
A	49	41.2	43.8		2.0	WOH
A	50	40.0	-		-	NOT PROBED
A	51	39.75	40.75		1.0	WOH
A	52	39.0	40.0		1.0	WOH
B	43	37.0	40.0		3.0	4-17/11
B	44	37.2	38.2	38.2	1.0	92
B	45	30.0	31.5	31.5	1.5	12-92/52
B	46	32.0	32.0	32.0	0.0	REFUSAL AT SURFACE
B	47	38.7	41.7		3.0	3-5/4
B	48	39.3	40.3		1.0	WOH
B	49	31.5	32.5	32.5	1.0	13/13
B	50	22.5	27.0	27.0	4.5	3-14/10
B	51	24.75	26.75	26.75	2.0	3-5/4
B	52	35.0	37.0	37.0	2.0	4-50/27
C	42	20.7	41.7	-	21.0	12-50/26
C	43	33.8	36.8	36.8	3.0	WOH-36 for 6"/12
C	44	25.8	27.8	29.8	2.0	6-64/35
C	45	27.7	27.7	27.7	0.0	REFUSAL AT SURFACE
C	46	33.5	41.5	-	8.0	3-16/8
C	47	27.2	36.2	36.2	9.0	1-69/24/
C	48	22.25	26.5	26.5	4.25	2-6/4/FINE SAND & SILT
C	49	22.5	32.5	32.5	10.0	1-58/16
D	42	10.0	40.0		30.0	WOH-54/23/CLAY,M-F SAND
D	43	14.2	39.2	39.2	25.0	WOH-94/18/BLUE CLAY
D	44	18.5	20.0	20.0	1.5	4-100 for 6"/69
D	45	20.2	21.7	21.7	1.5	50-80 FOR 6"/87
E	13	34.75	37.75	37.75	3.0	13-58/35
E	14	37.5	39.0	39.0	1.5	10-18 FOR 6"/14
E	15	34.5	41.5	41.5	7.0	4-74/33
E	16	41.0	-	-	-	NOT PROBED
E	17	43.0	-	-	-	" "
E	18	40.25	-	-	-	" "
F	13	17.0	24.25	24.25	7.25	7-20 FOR 3"/28
F	14	16.75	23.75	23.75	7.0	2-69/22
F	15	19.75	26.75	26.75	7.0	1-49/12
F	16	23.5	33.5	33.5	10.0	1-39/12
F	17	31.5	35.5	35.5	4.0	2-19/7
F	18	28.3	36.5	36.5	8.2	2-90/22
F	21	39.0	40.0	-	1.0	WOH
F	22	42.5	-	-	-	NOT PROBED
F	23	41.75	-	-	-	" "
F	24	37.25	43.25	-	6.0	WOH-15/6
F	25	38.5	44.5	-	6.0	WOH-3/1
F	26	39.0	44.0	-	5.0	WOH
F	27	39.7	40.7	-	1.0	WOH
F	28	41.5	42.5	-	1.0	WOH
F	29	42.0	-	-	-	NOT PROBED
F	30	35.0	36.0	36.0	1.0	81/81
F	31	37.0	40.0	-	3.0	WOH-49/26
F	32	39.0	41.0	-	2.0	WOH
F	33	37.3	41.3	-	4.0	WOH-9/2/SILT AND SAND
F	34	41.25	42.25	-	1.0	WOH
F	35	42.25	44.25	-	2.0	WOH-4
F	36	37.0	40.0	-	3.0	10-35/24/CLAY,V. FINE SAND
F	37	39.5	41.5	-	2.0	3-7
F	38	40.5	42.5	-	2.0	2-6
F	39	42.7	-	-	-	NOT PROBED
F	40	41.3	43.1	-	1.8	WOH-2
G	13	16.75	22.25	22.25	5.5	13-58 FOR 6"/33/F. SAND+SILT
G	14	14.75	23.75	23.75	9.0	5-60/19
G	16	11.0	23.0	23.0	12.0	1-40/16
G	17	17.0	27.5	27.5	9.5	3-39 FOR 6"/23
G	18	19.7	32.7	32.7	13.0	1-43/18/F. SAND+SILT
G	19	21.0	34.0	34.0	13.0	9-50/20/CLAY
G	20	29.75	39.75	39.75	10.0	1-30/12
G	21	31.5	38.5	38.5	7.0	1-18/6
G	22	37.5	40.5	-	3.0	1-2/1
G	23	38.0	41.0	-	3.0	4-6/5
G	24	27.0	40.0	-	13.0	WOH-12/3/SILT, CLAY, SHELLS
G	25	29.75	40.75	-	11.0	WOH
G	26	33.5	40.5	-	7.0	4-17/11/SILT AND SAND
G	27	30.5	40.5	-	10.0	2-11/5
G	28	30.5	40.5	-	10.0	WOH-11/4/SILT
G	29	28.0	41.0	-	13.0	2-13/6/SAND AND SILT
G	30	1.75	15.75	15.75	14.0	8-89/40
G	31	8.8	21.8	27.8	13.0	8-81/26/SILT+SAND

LIST OF PROBINGS

LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
		LOCATION	ELEVATION BELOW M.L.W.			
G	32	17.8	31.8	31.8	14.0	7-96/43/SILT AND SAND
G	33	27.5	40.5	-	13.0	6-33/22
G	34	30.75	34.75	34.75	4.0	1-6/4
G	36	8.5	20.5	20.5	12.0	13-87/34
G	37	18.5	31.5	31.5	13.0	9-124/40/F. SAND & SILT
G	38	18.4	30.4	30.4	12.0	10-71/24
G	39	12.5	31.5	31.5	19.0	4-72/36
G	40	21.8	33.8	33.8	12.0	10-96/47
G	41	28.5	40.0	-	11.5	WOH-23/11
H	13	7.5	9.0	9.0	1.5	2-2 FOR 6/2
H	14	8.0	16.0	16.0	8.0	2-28/10
H	15	9.5	15.5	15.5	6.0	2-41/13
H	16	9.0	16.0	16.0	7.0	1-48/14
H	17	9.5	10.5	10.5	1.0	60/60/VERY HARD
H	18	20.5	33.5	33.5	13.0	2-93/35/GR. SILT & SAND, CLAY
H	19	20.0	36.0	36.0	16.0	2-54/21
H	20	25.0	39.0	39.0	14.0	WOH-98/34
H	21	25.75	31.75	31.75	6.0	WOH-15/4
H	22	21.5	40.5	-	19.0	WOH-22/6
H	23	20.0	40.0	-	20.0	WOH-16/4
H	24	20.0	40.0	-	20.0	WOH-3/WOH
H	25	19.0	41.0	-	22.0	WOH-3/WOH
H	26	17.2	40.2	-	23.0	WOH-45/13
H	27	16.5	39.0	39.0	22.5	WOH-26/5/SILT,CLAY,SHELLS
H	28	15.5	30.5	30.5	15.0	4-15/9/CLAY,SHELLS,F. SAND
H	29	14.3	34.9	34.9	20.6	WOH-100/23
H	3.0	7.0	13.0	13.0	6.0	1-11/5
H	31	3.5	12.5	12.5	9.0	1-14/5
H	32	3.75	11.75	11.75	8.0	1-30/16/GR. SILT, F. SAND
H	33	2.0	11.0	11.0	9.0	1-62/11
H	34	2.5	21.0	21.0	18.5	2-64/27
H	35	0.25	24.75	24.75	24.5	1-48/18/SAND,SILT,CLAY
H	36	0.25	25.25	25.25	25.0	1-33/12
H	37	0.5	35.5	35.5	35.0	1-47/13/SILT & SAND
H	38	5.5	33.5	33.5	28.0	1-61/24
H	39	0.5	28.5	28.5	28.0	1-60/27/SAND,SILT,CLAY
H	40	2.5	23.0	23.0	20.5	WOH-65 FOR 6"/26/SAND,SILT,CLAY
H	41	4.5	40.5	-	36.0	WOH-38/16/CLAY,SHELLS,SAND
I	18	11.75	24.75	24.75	13.0	1-55/26/SILT,CLAY, F. SAND
I	19	10.75	24.25	24.25	13.5	WOH-91/24/SILT,SAND,CLAY
I	20	13.75	23.75	23.75	10.0	1-27/12/SAND & SILT
I	21	17.25	26.25	26.25	9.0	3-27/5
I	22	14.0	26.0	26.0	12.0	WOH-29/7
I	23	16.5	33.5	33.5	17.0	WOH-26/10
I	25	13.3	40.3	-	27.0	WOH-73/34
I	27	12.5	34.0	34.0	21.5	WOH-24 for 6"/4/SILT,SHELL,CLAY
I	28	14.0	31.5	31.5	17.5	WOH-16/8
I	29	12.5	26.5	26.5	14.0	WOH-53/12
I	30	4.75	25.25	25.25	20.5	WOH-52/SILT + CLAY
I	31	1.5	21.5	21.5	20.0	1-47/12/SILT
I	32	3.0	23.0	23.0	20.0	WOH-80/22
I	33	3.0	15.0	15.0	12.0	4-61/23/SILT
I	34	1.25	24.25	24.25	23.0	3-50/20
I	35	0.0	17.0	17.0	17.0	1-80/22/SAND,SILT, CLAY
I	36	+0.5	5.5	5.5	6.0	1-18/9
I	38	1.0	22.0	22.0	21.0	WOH-96/34/SILT+SAND
I	39	0.0	23.0	23.0	23.0	1-75/23/SILT+ORGANICS
I	40	+0.75	30.75	30.75	31.5	WOH46/18/SAND,SILT,CLAY
I	41	7.9	40.9	-	33.0	WOH-27/18/CLAY,F. SAND
J	20	12.0	28.0	28.0	16.0	1-55/16
J	21	12.25	27.75	27.75	15.5	WOH-37 FOR 6"/13
J	22	25.0	40.0	-	15.0	WOH-25/6
J	23	9.75	36.75	36.75	27.0	WOH-67/20
J	24	15.0	38.0	38.0	23.0	2-79/37/SILT, SAND
J	25	9.5	32.5	32.5	23.0	WOH-89/18
J	26	11.0	41.0	-	30.0	WOH-83/23
J	27	10.0	35.0	35.0	25.0	WOH-78/17/SILT
J	29	12.25	26.25	26.25	14.0	WOH-33/7/POSSIBLE BOULDER
J	30	4.25	24.0	24.0	19.75	WOH-45 for 7.5"/11 SAND,SILT,CLAY
J	31	0.75	26.75	26.75	26.0	2-72/20/SAND, SILT
J	32	1.5	23.0	23.0	21.5	WOH-40 FOR 6"/16
J	33	1.25	22.25	22.25	21.0	1-67/17/SAND, SILT
J	34	2.75	31.25	31.25	28.5	3-55/22
J	35	0.25	29.25	29.25	29.0	WOH-52/20
J	36	+1.0	28.0	28.0	29.0	WOH-46/17
J	37	+0.5	32.0	32.0	32.5	WOH-4 for 6"/23/SAN
J	39	0.0	26.0	26.0	26.0	WOH-56/19/ORGANIC SILT
J	39	+1.0	18.0	18.0	17.0	WOH-29/14
J	40	1.5	15.5	15.5	14.0	1-27/14/ORGANIC SILT
K	22	12.0	16.0	16.0	4.0	3-16/10/Possible boulder/Cobbles



AREA I
PROBE & BORING LAYOUT

(50FT. GRID EXCEPT AS SHOWN)

SCALE 1" = 100'

AREA BOUNDARY COORDINATES

POINT	NORTH	EAST
A	92,435.47	342,018.19
B	92,145.02	342,297.72
C	91,842.31	342,374.07
D	91,308.41	342,225.13
E	91,077.79	342,283.30
F	90,611.45	342,721.37

CHANNEL BOUNDARY COORDINATES

9	90,701.39	342,499.69
10	91,065.74	342,157.43
11	92,386.56	341,824.27
12	92,771.03	341,274.32

LEGEND

- • MACHINE PROBE
- ⊙ BORING
- ---(-35) BOTTOM CONTOUR MLW

LIST OF PROBINGS

LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
		LOCATION	ELEVATION BELOW M.L.W.			
K	23	10.25	31.25	31.25	21.0	3-78/28/SAND,SILT
K	24	8.0	28.0	28.0	20.0	1-67/19/SAND, SILT
K	25	8.25	25.25	25.25	17.0	WOH-63/16/SAND,SILT
K	26	9.75	25.75	25.75	16.0	WOH-47/18/SAND,SILT
K	27	9.0	42.0	42.0	33.0	WOH-62/22/silt,clay,froc.shells
K	28	7.25	29.25	29.25	22.0	WOH-34/14
K	29	5.0	32.0	32.0	27.0	1-69/18/SAND,SILT
K	30	4.5	31.0	31.0	26.75	8-63 for 7.5"/22/f.sand,inorg.silt,clay
K	31	0.25	21.75	21.75	21.5	1-65 for 6"/27/f.sand,inorg.silt,clay
K	32	0.0	27.0	27.0	27.0	WOH-41/22/SAND,SILT,CLAY
K	33	0.5	26.0	26.0	25.5	WOH-53 FOR 6"/ORGANIC SILT
K	34	0.0	28.0	28.0	28.0	WOH-57/28
K	35	+0.25	27.25	27.25	27.5	WOH-53 FOR 6"/21
K	36	+3.0	27.0	27.0	30.0	WOH-67/23
K	37	0.75	22.75	22.75	22.0	WOH-60/22
K	38	0.75	8.75	8.75	8.0	WOH-65/8/ORGANIC SILT
L	24	0.5	10.0	10.0	9.5	1-50 FOR 6"/4
L	25	8.0	21.5	21.5	13.5	1-47 FOR 6"/9
L	26	8.25	22.75	22.75	14.5	WOH-38 FOR 6"/13/Sand+Silt
L	27	9.0	31.0	31.0	22.0	WOH-34/11/SAND+SILT
L	28	7.5	28.5	28.5	21.0	WOH-18/7/SAND+SILT
L	29	3.0	28.5	28.5	25.5	WOH-36/13/SAND+SILT
L	30	2.25	24.75	24.75	22.5	WOH-49 For 6"/13/fine-med.Sand
L	31	1.25	23.25	23.25	22.0	WOH-31/15/SAND+SILT+CLAY
L	33	1.25	23.75	23.75	22.5	WOH-39/13/SAND+SILT+CLAY
L	34	0.75	26.75	26.75	26.0	WOH-58/19/SAND+SILT+CLAY
L	35	2.0	27.0	27.0	25.0	WOH-41/15
L	36	1.5	26.5	26.5	25.0	WOH-50/14/SAND+SILT+CLAY
L	37	+1.0	27.5	27.5	28.5	WOH-53 FOR 6"/13/SAND+SILT
M	25	6.25	23.75	23.75	17.5	WOH-49 FOR 6"/24
M	26	6.5	26.0	26.0	19.5	WOH-46 FOR 6"/18
M	27	10.25	35.75	35.75	25.5	3-47 FOR 6"/21/Sand+Silt+Clay
M	28	6.75	35.25	35.25	28.5	WOH-51 FOR 6"/12/SAND+SILT+CLAY
M	29	4.25	27.0	27.0	22.75	WOH-46 FOR 9"/11/f-m.sand,silt,clay
M	30	3.25	23.75	23.75	20.5	WOH-39 FOR 6"/10/Sand,S
M	31	0.25	15.75	15.75	15.5	1-32 for 6"/23/f-m.sand,silt,clay
M	32	0.75	15.75	15.75	15.0	1-53/18/FINE SAND
M	33	0.0	18.0	18.0	18.0	WOH-57/21/fine SAND,SILT,CLAY
M	34	0.75	22.25	22.25	21.5	WOH-46 for 6"/13/fine-med.sand
M	35	0.5	23.5	23.5	23.0	1-42/11/SAND+SILT+CLAY
N	27	8.25	26.25	26.25	18.0	8-55/24/SAND+SILT+CLAY
N	28	6.5	36.5	36.5	30.0	WOH-45/13/SAND+SILT+CLAY
N	29	3.25	35.75	35.75	32.5	WOH-47 for 6"/15/Sand,Silt+Clay
N	30	3.75	35.75	35.75	32.0	WOH-41/9/f.sand,silt,+clay
N	31	+2.25	24.0	24.0	26.75	WOH-47 for 6"/9/sand,silt,+clay
N	32	+0.25	26.25	26.25	26.5	WOH-42 for 6"/9/sand,silt,+clay
N	33	0.25	27.25	27.25	27.0	WOH-48/12/SAND,SILT,+CLAY
O	7	41.0	-	-	-	NOT PROBED
O	8	42.5	-	-	-	" "
O	9	40.5	-	-	-	" "
O	10	39.0	40.0	-	1.0	12
O	11	39.5	40.5	-	1.0	10
O	12	38.25	40.25	-	2.0	8-10

LIST OF PROBINGS

LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
		LOCATION	ELEVATION BELOW M.L.W.			
P	2	36.5	40.5	-	4.0	3-28/15
P	3	34.5	40.5	-	6.0	4-24/14
P	4	32.0	36.5	36.5	4.5	8-45 FOR 6"/23
P	5	27.5	40.5	-	13.0	6-48/30
P	6	18.5	20.5	20.5	2.0	6-12/9
P	8	6.5	10.5	10.5	4.0	6-75/28
P	9	4.5	4.5	4.5	0.0	REFUSAL AT SURFACE
P	10	9.0	20.0	20.0	11.0	4-43/16/SAND+SILT
P	11	12.5	18.5	18.5	6.0	4-42/7/SILT
P	12	16.5	24.5	24.5	8.0	10-39/25/SILT
Q	1	41.5	-	-	-	NOT PROBED
Q	2	35.5	40.5	-	5.0	1-5/3
Q	3	23.75	40.75	-	17.0	1-47/24
Q	4	19.0	31.0	31.0	12.0	2-60/25
Q	5	18.0	31.0	31.0	13.0	2-61/27
Q	6	9.5	14.5	14.5	5.0	3-11/6
Q	7	5.7	10.75	10.75	5.0	2-48/13
Q	8	3.25	3.25	3.25	0.0	REFUSAL AT SURFACE
Q	9	8.0	16.0	16.0	8.0	6-62/31/SILT + CLAY
Q	10	5.75	13.75	13.75	8.0	1-36/16
Q	11	5.8	11.8	11.8	6.0	WOH-48/17 POSSIBLE BOULDER
R	1	37.5	-	-	-	NOT PROBED PER ORDER OF PROJECT ENGINEER
R	2	27.75	-	-	-	" "
R	3	21.0	33.0	33.0	12.0	WOH-49/15
R	4	17.25	25.25	25.25	8.0	1-37/9/POSSIBLE BOULDER
R	5	13.25	21.25	21.25	8.0	8-42/20
R	6	6.0	6.0	6.0	0.0	REFUSAL AT SURFACE
R	7	2.2	2.2	2.2	0.0	" " "
R	8	0.9	0.9	0.9	0.0	" " "
R	9	1.8	1.8	1.8	0.0	" " "
R	10	6.0	6.0	6.0	0.0	" " "
P	11	3.25	4.25	4.25	1.0	4/4
RR	4	12.0	12.0	12.0	0.0	REFUSAL AT SURFACE
RR	5	4.5	4.5	4.5	0.0	REFUSAL 50/0"
RR	6	4.25	4.25	4.25	0.0	" "
RR	7	+3.0	+3.0	+3.0	0.0	REFUSAL AT SURFACE
RR	8	+2.6	+2.6	+2.6	0.0	" " "
RR	9	+1.2	+1.2	+1.2	0.0	" " "
RR	10	1.4	1.4	1.4	0.0	" " "
RR	11	3.3	3.3	3.3	0.0	" " "

NOTE:
Refusal defined as 50 blows with no penetration or bouncing refusal.

SAFETY PAYS

LEGEND FOR PROBE DATA BLOW COUNTS

CLAYS		SILTS + SANDS		SANDS+GRAVELS
V. Soft	0-5	V. loose	0-5	-
Soft	5-10	loose	5-10	-
m. Stiff	10-38	m. compact	10-38	loose
Stiff or m. Hard	38-72	compact	38-72	m. compact
Very Hard	72-100	v. compact	72-100	compact

NOTE:
Refusal defined as 50 blows with no penetration or bouncing refusal.

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY W.C. | DR. BY R.O.P. | CK. BY

SUBMITTED:
CHIEF, DESIGN SECTION
APPROVAL RECOMMENDED:
CHIEF, GEOTECH.ENG. BRANCH
REVIEWED
PROJECT MANAGER
APPROVAL RECOMMENDED:
CHIEF, PROJECT MNGT. BRANCH

PORTSMOUTH HARBOR AND PISCATAQUA RIVER, ME. & N.H.
AREA I
PROBE AND BORING LAYOUT AND PROBE DATA

APPROVED
CHIEF, ENGINEERING DIVISION
DATE OCT 1985

SCALE | SPEC. NO. DACW 33
DRAWING NUMBER
SHEET

PLATE IA

CORPS OF ENGINEERS — U. S. ARMY

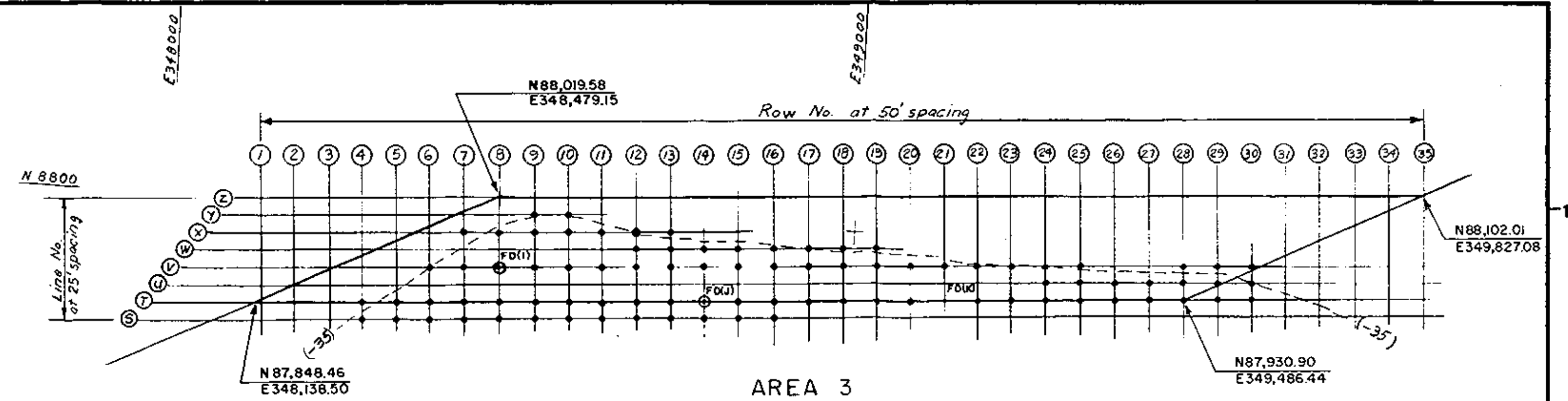
LIST OF PROBINGS

LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
		LOCATION / ELEVATION BELOW M.L.W.				
S	4	43.75	—	—	—	NOT PROBED
S	5	33.0	35.0	35.0	2.0	4/4
S	6	23.75	24.75	24.75	1.0	29/29
S	7	14.0	17.0	17.0	3.0	20-71/51
S	8	14.0	16.0	16.0	2.0	4-21/13
S	9	13.0	16.0	16.0	3.0	9-30/23
S	10	11.5	17.0	17.0	5.5	26-80/61
S	11	14.0	19.5	19.5	5.5	WOH-55/21
S	12	16.0	22.0	22.0	6.0	WOH-47/13/green silt,shells,f.sand,clay
S	13	19.5	26.5	26.5	7.0	WOH-15/5/Silt + Sand
S	14	23.0	29.0	29.0	6.0	WOH-79/22/green Silt,Shells,f.Sand
S	15	23.5	29.5	29.5	6.0	WOH-28/12/Silt + Sand
S	16	20.0	35.0	35.0	15.0	WOH-62/20
T	4	49.5	–	–	–	NOT PROBED
T	5	40.0	–	–	–	" "
T	6	29.25	31.25	31.25	2.0	3-27/15
T	7	11.5	11.5	11.5	0.0	Refusal at surface
T	8	14.25	17.25	17.25	3.0	6-39/21
T	9	14.25	16.25	16.25	2.0	6-39/23
T	10	11.75	13.75	13.75	2.0	6-9/8
T	11	13.5	19.5	19.5	6.0	3-49/12
T	12	16.0	24.0	24.0	8.0	2-64/27
T	13	15.25	23.25	23.25	8.0	2-21/10
T	15	22.0	30.0	30.0	8.0	WOH-43/18
T	16	23.5	32.5	32.5	9.0	1-40/20/Silt + Sand
T	17	21.5	24.0	24.0	2.5	1-42/20
T	18	19.0	28.0	28.0	9.0	6-60/30
T	19	19.25	26.25	26.25	7.0	6-62/18
T	20	21.25	33.25	33.25	12.0	4-72/23
T	22	24.5	40.5	–	16.0	2-36/22
T	23	26.0	34.0	34.0	8.0	1-75/25/Possible boulder
T	24	28.75	40.75	—	12.0	4-31/18
T	25	27.0	33.0	33.0	6.0	WOH-21/7
T	26	26.5	33.5	33.5	7.0	3-23/13 Silt + Sand
T	27	27.0	34.0	34.0	7.0	5-31/17
T	28	27.5	33.5	33.5	6.0	8-72/30/green Silt
T	29	29.0	32.0	32.0	3.0	11-31/20
T	30	29.5	32.5	32.5	3.0	7-67/32
U	24	33.5	40.5	40.5	7.0	3-25/12
U	25	33.25	40.25	–	7.0	2-59/21
U	26	33.0	38.0	38.0	5.0	7-63/25
U	27	34.5	39.5	39.5	5.0	2-94/42/green Silt
U	28	34.5	38.5	38.5	4.0	8-29/18
U	29	34.75	41.75	–	7.0	WOH-57/24
U	30	36.5	40.5	–	4.0	WOH-5/3
V	6	49.0	–	–	–	NOT PROBED
V	7	19.5	19.5	19.5	0.0	Refusal at surface
V	9	11.25	11.25	11.25	0.0	Refusal at surface
V	10	15.25	18.25	18.25	3.0	15-80/42
V	11	22.25	23.75	23.75	1.5	4-12
V	12	23.5	30.5	30.5	7.0	19-76/37
V	13	23.75	28.25	28.25	5.0	2-19/17
V	14	22.5	33.5	33.5	11.0	1-30/13
V	15	25.25	36.25	36.25	11.0	1-46/21/Silt + Sand
V	16	28.5	32.5	32.5	4.0	WOH-53/19
V	17	30.75	40.75	–	10.0	1-23/11
V	18	30.5	40.5	–	10.0	WOH 33/11
V	19	32.25	40.25	–	5.0	WOH
V	20	33.75	40.75	–	7.0	"
V	21	35.0	40.0	–	5.0	"
V	22	37.75	42.75	–	5.0	"
V	23	40.0	—	—	—	NOT PROBED
V	24	43.5	–	–	—	" "
V	25	39.0	41.0	–	2.0	WOH
V	28	46.5	—	—	—	NOT PROBED
V	29	46.75	—	—	—	" "
V	30	48.0	—	—	—	" "
W	12	27.5	28.5	28.5	1.0	32/Possible boulder
W	13	32.0	40.0	–	8.0	WOH-28/13
W	14	31.5	40.5	–	9.0	3-51/25/Silt + Sand
W	15	31.0	40.0	–	9.0	WOH-56/31/green silt,f.sand,shells
W	16	34.0	40.0	–	6.0	WOH-59/25
W	17	36.0	40.0	–	4.0	WOH-4/1
W	18	37.75	40.75	–	3.0	WOH
W	19	39.0	40.0	–	1.0	"
X	7	52.0	54.0	–	2.0	"
X	8	43.25	—	—	—	NOT PROBED
X	9	36.5	36.5	36.5	0.0	Refusal at surface
X	10	31.0	32.0	32.0	1.0	7/7
X	11	29.75	29.75	29.75	0.0	Refusal at surface

LIST OF PROBINGS

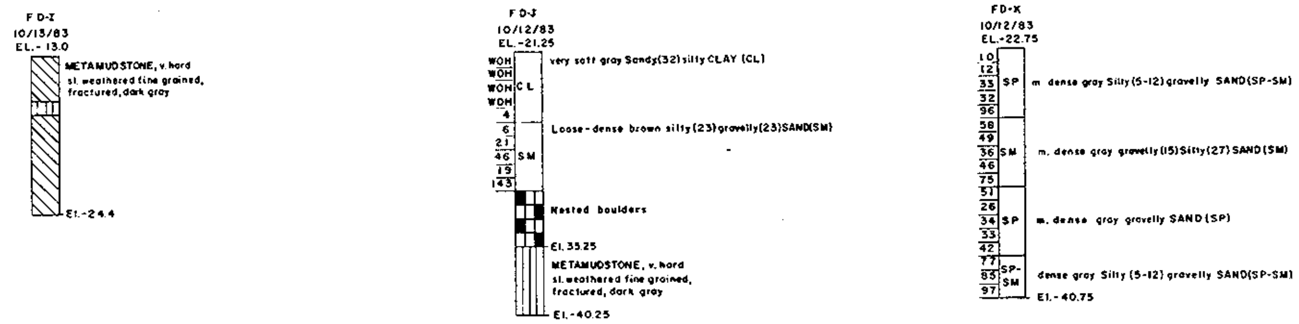
LINE NO.	ROW NO.	GROUND ELEVATION	ELEV. BOTTOM OF PROBE	ELEV. AT REFUSAL	PENETRATION	BLOWS PER FT. IN ZONE OF PENETRATION RANGE/AVERAGE/REMARKS
X	12	35.5	37.5	37.5	2.0	1-3/2
X	13	—	—	—	—	NOT PROBED CLOSE OF BORING
Y	9	41.0	—	—	—	" " " " "
Y	10	37.0	37.0	37.0	0.0	Refusal at surface

NOTE:
Refusal defined as 50 blows with no penetration or bouncing refusal.



AREA 3
PROBE & BORING LAYOUT
SCALE: 1" = 100'

LEGEND FOR LAYOUT
- MACHINE PROBE
- BORING
- ----(-35) BOTTOM CONTOUR M.L.W.



SCALE: 1" = 5' Vert.

LEGEND FOR FOUNDATION DRILL HOLES

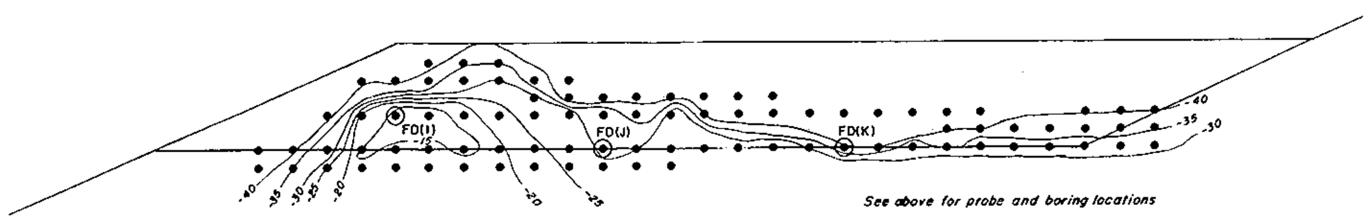
FDJ Type and number of exploration
10-12-83 Month/Day/Year exploration completed
El.-12.25 Elevation of ground surface at time of exploration

WOH Penetration by weight of "AW" Rods and 300# hammer
SM Group letter symbol according to Unified Soil Classification System
39 Number of blows per foot of penetration or as indicated using a 300 pound hammer falling freely an average drop of 18 inches to drive a 5 foot sample spoon of 2" I.D.

Coarse gravel or nested cobbles and boulders.
El.9.65 Elevation of bedrock surface
Rock core recovery 0-25%
Rock core recovery 25-50%
Rock core recovery 50-75%
Rock core recovery 75-90%
Rock core recovery 90-100%
El 4.65 Elevation of bottom of exploration

NOTE: All Elevations Refer to Feet M.L.W.

SCALE: 1" = 5' Vert.



See above for probe and boring locations

AREA 3
ASSUMED BEDROCK CONTOUR
DATUM: M.L.W.
SCALE: 1" = 100'

SAFETY PAYS

GRAPHIC SCALES
1" = 5' — 5' 0 5' 10'
1" = 100' — 100' 0 100' 200'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

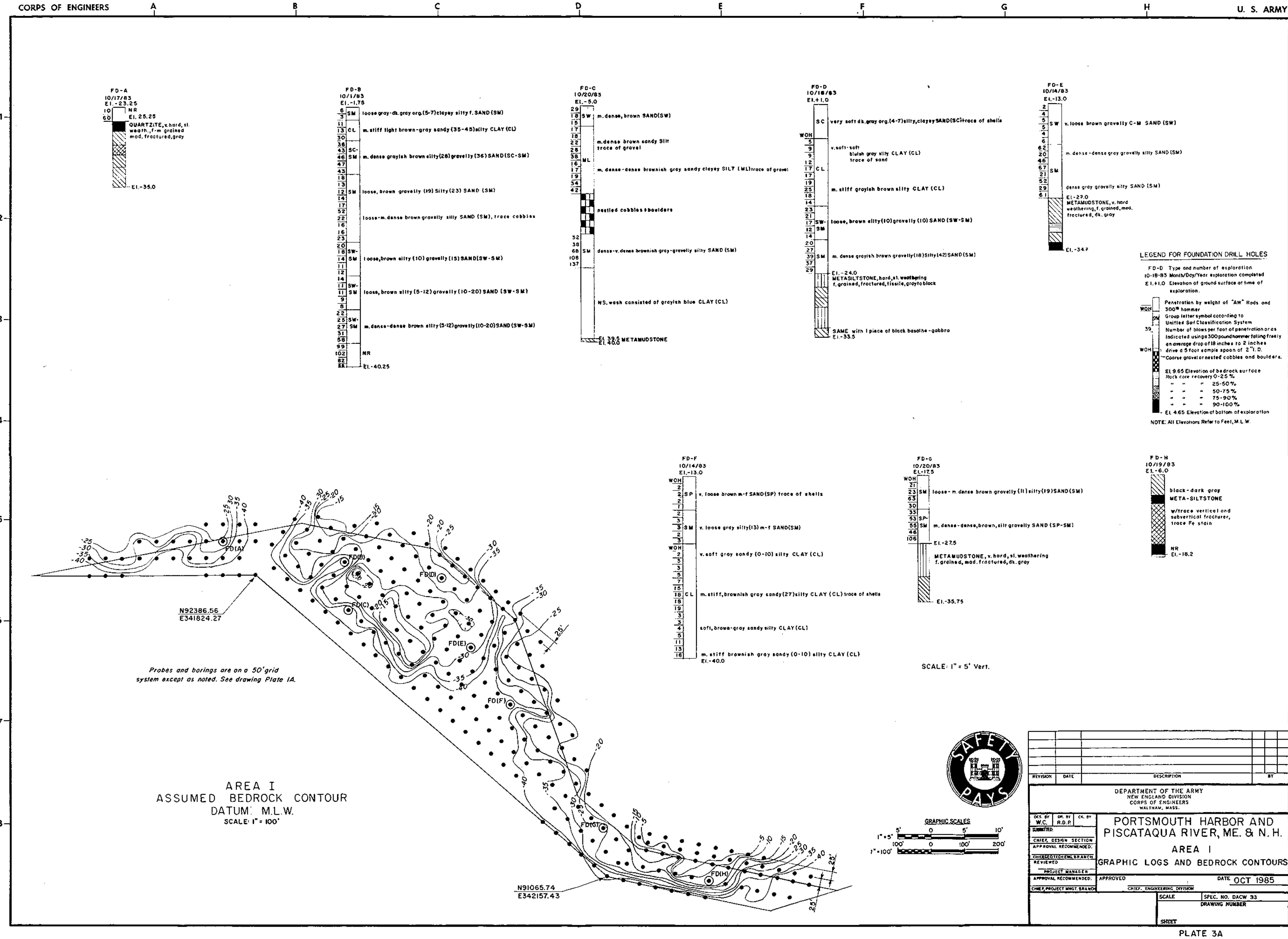
DES. BY W.C. | DR. BY R.O.P. | CK. BY
SUBMITTED: CHIEF, DESIGN SECTION
APPROVAL RECOMMENDED: CHIEF, GEO. TECH. ENG. BRANCH
REVIEWED: PROJECT MANAGER
APPROVAL RECOMMENDED: CHIEF, PROJECT MNGT. BRANCH

PORTSMOUTH HARBOR AND PISCATAQUA RIVER, ME. & N. H.
AREA 3
PROBE AND BORING LAYOUT
PROBE DATA AND GRAPHIC LOGS, BEDROCK CONTOURS

APPROVED — CHIEF, ENGINEERING DIVISION — DATE OCT 1985

SCALE AS SHOWN | SPEC. NO. DACW 33
DRAWING NUMBER
SHEET

PLATE 2A


CORPS OF ENGINEERS
U. S. ARMY
FD-A 10/17/83 El.-23.25
FD-B 10/1/83 El.-1.75
FD-C 10/20/83 El.-5.0
FD-D 10/18/83 El.+1.0
FD-E 10/14/83 El.-13.0
FD-F 10/14/83 El.-13.0
FD-G 10/20/83 El.-17.5
FD-H 10/19/83 El.-6.0
LEGEND FOR FOUNDATION DRILL HOLES
NOTE: All Elevations Refer to Feet, M.L.W.
SCALE: 1" = 5' Vert.
Probes and borings are on a 50' grid system except as noted. See drawing Plate 1A.
N92386.56
E341824.27
N91065.74
E342157.43
AREA I
ASSUMED BEDROCK CONTOUR
DATUM: M.L.W.
SCALE: 1" = 100'
GRAPHIC SCALES
SAFETY PAYS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
PORTSMOUTH HARBOR AND
PISCATAQUA RIVER, ME. & N. H.
AREA I
GRAPHIC LOGS AND BEDROCK CONTOURS
DATE OCT 1985
SPEC. NO. DACW 33
PLATE 3A

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT. M.L.W.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS			PERCENT ORGANIC MATTER
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	STND AASHO OPT. WATER % DRY WT	STND AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL	PERM.	
FD-B	-1.75	S-1	0-2	SM			44	.004	94	41	2.75											5.51
	-3.75	S-1A	2-5	CL					39	18	2.79											
	-6.75	S-2	5-10	SC-SM	36	36	28															
	-11.75	S-3	10-15	SM	19	59	22															
	-21.75	S-5	15-20	SW-SM	15	75	10	.075														
FD-D	+1.0	S-1	0-5	SC			47	.01	99	40	2.75											5.36
	-4.0	S-2	5-10	CL					46	20	2.81											
	-14.0	S-4	15-20	SW-SM	10	80	10	.075														
	-19.0	S-5	20-25	SM	18	40	42															
FD-F	-18.0	S-2	5-10	SM	0	87	13															
	-23.0	S-3	10-15	CL					36	19	2.79											
	-28.0	S-4	15-20	CL	0	27	73		31	17	2.78											
FD-G	-17.5	S-1	0-5	SM	11	70	19															
FD-J	-21.25	S-1	0-5	CL					39	19	2.75											
	-26.25	S-2	5-10	SM	23	54	23															
FD-K	+27.75	S-2	5-10	SM	15	57	28															

* PROVIDENCE VIBRATED DENSITY TEST

APPENDIX B

SHIP SIMULATION MODEL STUDY

(Executive Summary Only)

APPENDIX B

AN EVALUATION OF THE EFFECTIVENESS OF A PROPOSED CHANNEL DESIGN MODIFICATION FOR NAVIGATION RISK MITIGATION IN PORTSMOUTH HARBOR

DRAFT

(Executive Summary Only)

Prepared for:

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Waltham, Massachusetts 02254

Prepared by:

CAORF Research Staff
Computer Aided Operations Research Facility
Maritime Administration
U.S. Department of Transportation
Kings Point, New York 11024

August 1985

THIS APPENDIX IS CURRENTLY IN THE PROCESS OF BEING FINALIZED. THE FINAL VERSION WILL CONTAIN SUBSTANTIALLY THE SAME INFORMATION AS CONTAINED HEREIN, WITH THE EXCEPTION OF MINOR EDITORIAL CHANGES WHERE DEEMED NECESSARY TO MORE CLEARLY DEFINE THE INFORMATION.

LEGAL NOTICE

EXECUTIVE SUMMARY

The purpose of the research detailed in this document was to evaluate the degree to which vessel and waterway safety is increased by a harbor modification plan designed to increase navigation safety in the Piscataqua River in Portsmouth Harbor. The harbor modification plan was developed by the United States Army Corps of Engineers - New England Division.

Portsmouth Harbor is formed by the Piscataqua River which is 13 miles long and constitutes a portion of the boundary between Maine and New Hampshire.

Movement of deep-draft vessels through the Harbor is made possible by a Federal project which provides for a 35-foot deep ship channel (see Figure 1). The channel is generally 400 feet wide in straight segments and up to 700 feet wide in turns.

The combination of sharp turns in close proximity, rock channel sidewalls, strong currents and angular bridge crossings with limited clearances makes the Piscataqua River Channel difficult to navigate safely.

Three factors in Portsmouth Harbor have been identified as particular risks to safe vessel transit: the channel bend at Henderson Point, the channel bend and segment between Badgers Island and the Maine - New Hampshire Interstate Bridge, and the physical configuration of the Maine - New Hampshire Interstate Bridge. In response to concern about safe deep-draft vessel navigation through these areas, the New England Division of the U.S. Army Corps of Engineers has formulated several navigation risk mitigation plans.

Of the alternative plans considered, one was evaluated as the most promising in terms of meeting navigation safety objectives while at the same time requiring a practical and realistic engineering effort. This plan is referred to as "Plan A".

Plan A was designed to improve the safety of vessel navigation in the Piscataqua River through the implementation of three channel design modifications.

- o Widening the existing emergency maneuvering area, which is located between the vertical lift bridges near the western end of Badgers Island, from its current 600-foot width to 1,000-foot width (see Area 1 on Figure 1).

- Widening by 100 feet, the northern limit of the channel at the southern end of the emergency maneuvering area adjacent to Badgers Island (see Area 1 on Figure 1).

- Widening by 150 feet, the southern portion of the channel at the bend in the vicinity of Goat Island from its current width of 400 feet to 550 feet (see Area 3 on Figure 1).

The benefits proposed to result from the widening of Area 1 include (1) the provision of an emergency maneuvering area in which large vessels could be turned before the Maine - New Hampshire Bridge should the lift portion of the bridge malfunction or the vessel become disabled, (2) the widening at Badgers Island may permit vessels to approach the Maine - New Hampshire Bridge (which is at an unfavorable angle) with better alignment since they would not have to move so far over toward the New Hampshire side of the channel thus making bridge transit safer, and (3) safer transit of the turn between the Memorial and Maine-New Hampshire Bridges.

The benefit proposed to result from the widening of Area 3 is safer transit of this currently troublesome turn.

The implementation of Plan A is contingent upon the findings that the design modifications significantly increase navigation safety. That is, that the risk mitigation effectiveness is sufficient to warrant the modification effort. The purpose of the study was to objectively evaluate whether the proposed plan is likely to meet its risk mitigation objectives.

The effect of any harbor design plan on navigation safety is based on the interaction of many factors including:

- Channel geometry
- Design vessel hydrodynamics and aerodynamics
- Prevailing current and wind forces
- Formal aids to navigation, such as ranges and buoys
- Informal navigational aids, such as land structures
- Visibility, ambient lighting, and other environmental effects
- Availability of vessel assistance, such as tugs
- Human operator control and decision processes.

Real-time, full-mission, shiphandling simulation provides a research tool with which the complex interactions of these factors can be examined. The U.S. Maritime Administration's Computer Aided Operations Research Facility (CAORF) houses one of the world's most sophisticated shiphandling simulators and, therefore, affords the opportunity to evaluate proposed harbor design plans prior to their implementation.

Since the harbor design modifications proposed for the Piscataqua River can be linked with two specific areas, Areas 1 and 3 in Figure 1, specific study objectives were formulated for each location.

Study Objectives Relating to The Badgers Island/Maine - New Hampshire Interstate Bridge Area (Area 1):

(a) To determine the differences in navigation safety in the modified (widened) turn as compared with the currently existing turn.

(b) To determine the differences in the safety of vessel passage through the Maine - New Hampshire Bridge under the widened channel configuration when compared with the currently existing channel configuration.

(c) To determine the operational feasibility of turning a disabled vessel with the assistance of tugs in an area between the Memorial and Maine - New Hampshire Bridges. This area represents the proposed 1,000-foot wide emergency maneuvering area. At present, large deep-draft vessels cannot turn at this location due to the width restriction of 600 feet.

Study Objectives Relating to The Turn at Henderson Point (Area 3):

To determine the differences in navigation safety in the modified (widened) turn as compared with the currently existing turn.

Study Objectives Relating to the USACE Channel Definition:

Much of the Piscataqua River outside the two study areas is deep enough to permit vessel navigation without the need for channel dredging. The USACE has identified, however, a channel boundary extending from deep water at the mouth of the harbor near New Castle, approximately 6.2 miles to Newington.

The boundaries throughout much of this channel exist on paper rather than as actual physical channel. This is the channel, however, that the USACE is responsible for maintaining in terms of providing safe vessel transit through the harbor. A third objective of this study was to determine the appropriateness of this channel definition with respect to actual pilot navigation of vessels through the waterway. That is, does the Federal channel correspond to the areas within the river actually transited by pilots.

The logical basis for evaluating the effectiveness of the Plan A Design rests on a comparison with the existing channel design. The desirability of implementing Plan A is predicated upon the assumption that Plan A will meet its objectives of providing for safer vessel transit than the currently existing design conditions. The research design of this study was developed to logically test that assumption, i.e., to determine whether the Plan A design leads to safer vessel navigation. To do so both the presently Existing design and the Plan A design were modelled. Portsmouth Harbor Pilots then conned a deep-draft vessel through both designs and data on ship position, ship controllability, and pilot response were recorded. These data then served as a basis upon which to compare the vessel navigation performance under the two design conditions. Statistical tests were also conducted to determine the reliability of the observed differences between the two designs, i.e., to ensure that the differences observed were not likely to be the result of random or chance variations in performance. This basic methodology enabled conclusions to be drawn as to the relative safety improvements of the Plan A design. For the purposes of orientation, a brief overview of methodology will be given in this section and the details of the research plan will be provided in subsequent sections.

Each of the three Portsmouth Harbor Pilots conned a 45,000 DWT tanker inbound from a location to the north of New Castle (see Figure 1) to a location either below or above the Maine - New Hampshire Bridge. The tanker was loaded to a draft of 37 feet and transited the channel with the assistance of three tug boats. Transits were made through two versions of Portsmouth Harbor: the Existing design and the harbor design representing Plan A. Plan A included the channel widening at Henderson Point and Badgers Island, and the channel widening in the emergency maneuvering area between Badgers Island and the Maine - New Hampshire Bridge. The harbor designs will be referred to as the existing and Plan A designs respectively.

Transits through the existing design were terminated when the vessel cleared the Maine - New Hampshire Bridge. One-half of the transits through the Plan A design were terminated when the vessel cleared the bridge. For the other transits through the Plan A design, the vessel encountered a rudder failure after clearing the Memorial Bridge when the vessel was abeam of Buoy "N16". The pilot then turned the vessel with tug assistance in the emergency maneuvering area. These transits were terminated when the turn maneuver had been completed and the vessel was under control. This type of transit was identified as an "emergency maneuver transit", while a transit which was terminated when the vessel cleared the Maine - New Hampshire Bridge was identified as a "complete transit".

Visibility variations (i.e., fog, darkness, snow white-out) can have a significant impact on vessel operations. While navigation may be accomplished primarily by means of visual cues from the waterway under fair conditions, restricted visibility diminishes the availability of navigation information. While vessel transits in the real world are primarily made under "unrestricted" visibility conditions, transits are also made under reasonable levels of restricted visibility. Therefore, pilots in this study were asked to make transits under both unrestricted and restricted visibility conditions.

The participants in this study were the three active Portsmouth Harbor Pilots. The three pilots had 23, 21, and 5 years of piloting experience in Portsmouth. They reported having handled vessels of the size used in the simulation 12, 10, and 2 times during the past year respectively. In addition, two bridge support persons participated. A helmsman carried out the pilot's course and rudder commands, and a mate assisted pilots in whatever way they deemed necessary.

Ownship was a ballasted 45,000 DWT tanker with a length of 652 feet and beam of 105 feet. The tanker was in ballast and had an even draft of 37 feet. The bridge of ownship was equipped with standard instrumentation composed of actual marine hardware like that found aboard large merchant vessels.

In addition, a CRT monitor was placed on the bridge in order to provide the pilot with information regarding tug deployment. Points of attachment and forces exerted by the tugs were represented graphically relative to an outline of ownship's hull.

Two models of Portsmouth Harbor were developed depicting the existing harbor design and the Plan A design. Each model of Portsmouth Harbor required five data bases: visual, radar, depth/current/bank (DCB), situation display, and plotting. These data bases were constructed from information collected from several sources. A current modelling and prediction effort for the current data base was conducted at the COE's Waterways Experiment Station (WES). Since detailed information on current velocities and magnitudes was not available, these data were prepared by WES. Following the collection of field data, WES modelled the existing current conditions using a finite element mathematical model. The model was then used to estimate changes in current patterns following the proposed modifications to the waterway. Current magnitudes and velocities at specific locations for the existing and modified waterway were incorporated into the CAORF current model.

The factors examined in this study were design model of Portsmouth Harbor (existing and Plan A), the type of transit (complete and emergency maneuver), and the level of visibility (restricted and unrestricted). With respect to practical considerations a complete combination of design model and transit type is unnecessary. Since the design vessel was too long to turn in the existing channel, an emergency maneuver transit in the existing channel design was not necessary.

Rather than combining the levels of these two factors, they were combined into one independent variable which was called Transit Condition. This variable had three levels:

- o Complete transit through the existing channel design
- o Complete transit through the Plan A design
- o Emergency maneuver transit through the Plan A design

The second independent variable was Visibility Condition which had two levels:

- o Unrestricted visibility (12 nm)
- o Restricted visibility (.5 nm)

A thorough comparison of the existing channel configuration with the Plan A configuration required the collection of dependent variables (performance measures) from four categories. The first two are perhaps most important since they directly relate to the safety objectives of the study. These were measures of the vessel's position in the channel and measures of proximity to the towers of the Maine - New Hampshire Bridge. The third category represented the vessel's controllability while making channel transits. The fourth set of measures related to the pilots' subjective evaluations of the channel designs under investigation.

The two independent variables under investigation were Transit Condition, having three levels, and Visibility Condition, having two levels. These two variables were combined to form six experimental conditions. Each of the three pilots made two transits in each of the experimental conditions.

Each pilot completed the experimental conditions in a different balanced sequence, with the exception that all pilots made their first three experimental transits in unrestricted visibility. The first of these transits was through the existing design; the second was through the Plan A design. The third transit was an emergency maneuver transit.

The six experimental conditions investigated required the development of six test scenarios. In addition, two scenarios were developed to provide simulator familiarization to the pilots. A total of eight scenarios were designed. The two familiarization scenarios were identified as scenarios A and B and the six test scenarios were identified as scenarios 1 through 6 to provide labels linking them with their corresponding experimental conditions. In this section these scenarios will be described in general terms.

The vessel's "destination" for the purposes of each scenario was the Atlantic Terminal Corporation Petroleum Wharf which is located about 3.5 miles above the Memorial Highway Bridge. This location was selected because it is the wharf furthest from the harbor entrance. Since pilots time their transits to arrive at the wharf at slack water, the further up river the vessel must go the stronger the current in the vicinity of the two areas of interest. Therefore, a transit to the Atlantic Petroleum Wharf represents the worst case with respect to current effects, i.e., the furthest from slack water. Since the same destination was used for all scenarios, the current for all scenarios represented a worst case flood condition for vessel transit.

Other environmental effects being held constant across scenarios included wind which was 5 knots from the northeast with a 20 degree variability. Transits occurred in ambient lighting conditions reflecting daytime.

Scenarios 1, 2, 3, and 4 represented complete transits but terminated when the vessel's stern cleared the Maine - New Hampshire Bridge (indicated as Point C on Figure 2). For the purpose of this study, that was considered a complete transit since transit all the way to the Atlantic Terminal was not necessary to meet the objectives of the study. For Scenarios 1 and 3, unrestricted visibility conditions prevailed, while for scenarios 2 and 4, visibility was restricted to .5 nm. For scenarios 1 and 2, the transits were made through the existing channel design. Transits in scenarios 3 and 4 utilized the modified, Plan A design.

Scenarios 5 and 6 represented emergency maneuver transits in which the vessel's rudder became disabled. For scenario 5 the visibility was unrestricted and for scenario 6 visibility was limited to .5 nm. The Plan A channel design was used for both scenarios.

The treatment of data for this study was performed at three levels. First, descriptions of each individual passage completed during the testing program were prepared. Second, data describing vessel proximity, controllability, and pilots' ratings were then summarized across experimental conditions (combinations of visibility and transit type conditions). Third, statistical tests were performed to determine the statistical reliability of differences observed in the data between the levels of the independent variables under investigation, especially transit type.

The Area 3 vicinity was divided into three segments for the analysis of vessel proximity and controllability measures. The Goat Island Approach segment described the channel area immediately prior to the proposed channel widening. The Goat Island segment corresponded to the area in which dredging would occur under Plan A. The Henderson Point Turn segment comprised the general vicinity of the Point.

The study objective for Area 3 was to identify differences between the Existing and Plan A channel designs with respect to the safety of navigation through the Henderson Point Turn. It was hypothesized that benefits associated with Plan A modifications would be evidenced by more favorable vessel positioning entering the turn and earlier initiation of the turn, resulting in a maneuver which was less demanding in terms of control force (rudder and tugs).

The analyses indicated that channel widening as proposed in Plan A did permit vessels to begin maneuvering for the turn much sooner than was possible in the Existing channel design. Evidence for this conclusion came from the significant differences between the two designs in heading, heading variability, average heading error, variability of heading error, and average rate of turn. All indices indicated preparations to bring the vessel to port when entering the widened segment at Goat Island.

Analyses of the Goat Island segment indicated the vessel in the Plan A design had greater starboard bank clearance when compared to the Existing design. Port bank clearances were greater as well. Hence vessel maneuvering preparations observed in the previous channel segment lead to improved vessel positioning to enter the turn. In addition, the Plan A design resulted in greater vessel maneuvering within this segment but this maneuvering was achieved with less control force. Average rudder, proportion of tug force utilized, and maximum tug forces were significantly less in the Plan A design as was the variability in rudder and tug usage. This is clearly a desirable result of the proposed channel widening associated with Plan A.

In the turn at Henderson Point, the Plan A design lead to superior starboard bank clearance but the difference was not statistically significant. Significant differences were found, however, on variables of rate of turn and tug force usage. In both cases the Plan A design lead to less variability than the Existing design. Plan A was also associated with less heading error, rudder angle required, average tug force, and maximum tug force but on these variables the differences were not statistically significant.

The weight of the evidence, however, including all trends in the data for the Henderson Point Turn, supported a conclusion that the Plan A channel widening in Area 3 led to safer transit of the turn. The widening resulted in earlier turning preparations, better alignment going into the turn, better positioning within the turn, and less control force required to execute the turning maneuvers.

The Area 1 vicinity was divided into four segments for the analysis of vessel position and controllability measures. The Memorial Bridge segment represented vessel passage under the Memorial Bridge. The Badgers Island segment extended from the Memorial Bridge through the turn at Badgers Island. This included the widening by 100 feet of the northern boundary of the turn in the Plan A design. The next segment was the Maine-New Hampshire Bridge Approach which extended from the turn at Badgers Island to the bridge. In the Plan A design the northern channel boundary in this area was widened from 600 to 1000 feet to permit both a more northerly bridge approach as well as an emergency maneuvering area should the vessel or bridge become disabled. Finally, the Maine-New Hampshire Bridge segment represented the area between the bridge piers where vessels must transit.

Analyses of vessel transits through this area under both Existing and Plan A channel design conditions were conducted to test several hypotheses related to the proposed channel widening embodied in the Plan A Design:

1. To determine whether navigation safety improved as a function of widening the turn at Badgers Island. Evidence in support of Plan A improvements were hypothesized to include increased port bank clearance and a more northerly heading through the Badgers Island turn area.

2. To determine whether Plan A widening would result in safer passage of vessels through the Maine-New Hampshire Bridge. Evidence in support of Plan A improvements were hypothesized to include (1) increased port bank clearance in the Maine-New Hampshire Bridge Approach segment and (2) while making bridge transits, a more favorable division of available horizontal clearance and a more favorable heading through the bridge thus increasing available width (less vessel crab angle during bridge transit).

3. To determine the operational feasibility of turning a disabled vessel with tug boat assistance in the Plan A emergency maneuvering area. Evidence in support of the Plan A widening would be the successful execution of a turning and stopping maneuver without grounding any portion of the vessel.

The data analysis supported each hypothesis and, therefore, the channel widening in Area 1 proposed in the Plan A Design.

The effects of Plan A channel widening of Area 1 were first detected in the Memorial Bridge segment. While vessel positioning between the two designs differed little, vessels in the Plan A design exhibited significantly greater rate of turn to port which indicated preparation of the vessel to utilize turn widening at Badgers Island. In addition, greater tug force was utilized in the Plan A design. Hence pilots were able to begin turning maneuvers earlier in the Plan A design.

Vessel Positioning differences were observed in the Badgers Island segment as hypothesized. Significantly greater port bank clearances were found in the Plan A design. A more favorable heading and lower heading error were also associated with the Plan A design, as hypothesized. The desired more northerly track line indicated by greater port bank clearances extended through the Maine-New Hampshire Bridge segment. So did the more favorable heading. Vessels in the Plan A design had a significantly lower heading and heading error when compared with the Existing channel design.

The more favorable vessel track position and heading angle resulting from Area 1 widening in Plan A has a significant effect on vessel transits through the Maine-New Hampshire Bridge. In theory, the most desirable method of bringing a ship through bridge piers is to minimize the ship-bridge clearance on both sides of the vessel, i.e., proceed through the center of the span. The ideal strategy must be modified in the real-world to compensate for pre- and post- bridge transit maneuvering requirements. In transiting the Maine-New Hampshire Bridge, inbound ships tend toward the western side of the span. Hence greater starboard than port clearance is available. It is desirable, therefore, to move inbound vessel track lines through the bridge to the east, thereby increasing port pier clearances. This effect was observed in the Plan A design. Vessels had significantly greater port pier clearances then in the Existing channel design. In addition and as important, the variability of vessel positioning was less in the Plan A design.

Another favorable impact of the Plan A design was that vessels transited the bridge at a more favorable heading angle which was three degrees less than the Existing design. This significant reduction in heading angle resulted in an increase in available horizontal clearance of approximately 10 feet between the piers. A ten foot increase in available clearance is quite significant when the available clearance is less than 100 feet as is the case with this bridge. This increase was due to the decreased crab angle of vessels in the Plan A design.

On some transits vessels became disabled following the turn at Badgers Island and a turning maneuver had to be accomplished. The Plan A design provided a 1000-foot emergency maneuvering area for the purpose of permitting large vessels to be turned in the event of a ship or lift bridge problem. Pilots in the present study attempted to turn and stop the 652-foot vessel within this area.

The analyses of these maneuvers indicated that when vessels were turned sufficiently into the emergency maneuvering area, the turn maneuver was successful in all cases. However, if the ship was not brought far enough into the area, problems were encountered when turning the vessel.

Hence it was concluded that the emergency maneuvering area was sufficient for turning vessels. Since these maneuvers were accomplished under conditions where the ship was disabled, it can logically be concluded that the maneuver would be successful in the event of a lift failure on the Maine-New Hampshire Bridge where a turning and stopping maneuver would be required by the non-disabled ship.

Based upon the results of this study, the following conclusions and recommendations are offered.

1. With respect to proposed channel widening in Area 3 of the Plan A Design, channel modifications were successful in allowing pilots to prepare for turning maneuvers sooner, and more safely execute the turn at Henderson Point Turn in the Existing Design. It is, therefore, recommended that this design modification be implemented.

2. With respect to the proposed channel widening in Area 1 of the Plan A Design, channel modifications resulted in earlier preparation for the Badgers Island turn thereby permitting a more northerly approach to and safer transit of the Maine - New Hampshire Bridge. It is therefore recommended that this channel modification be implemented.

3. With respect to the Plan A emergency maneuvering area, the proposed width is concluded to be sufficient for executing turning and stopping maneuvers with large deep-draft vessels. It is, therefore, recommended that this channel modification be implemented.

4. The success of the emergency maneuver was found to be functionally dependent upon bringing the bow of the vessel sufficiently into the emergency maneuvering area. Hence it is recommended that the marking of this area be studied by the USACE and U.S. Coast Guard to ensure that pilots can clearly determine the limits of the area. Once a marking scheme has been determined, pilot training on making emergency maneuvers within the area would be appropriate to ensure familiarity with the new emergency maneuvering area.

5. If Plan A is implemented as recommended, the USACE should consider aligning the formal channel definition of the western channel boundary with the 35-foot contour line in the vicinity of the emergency maneuvering area.

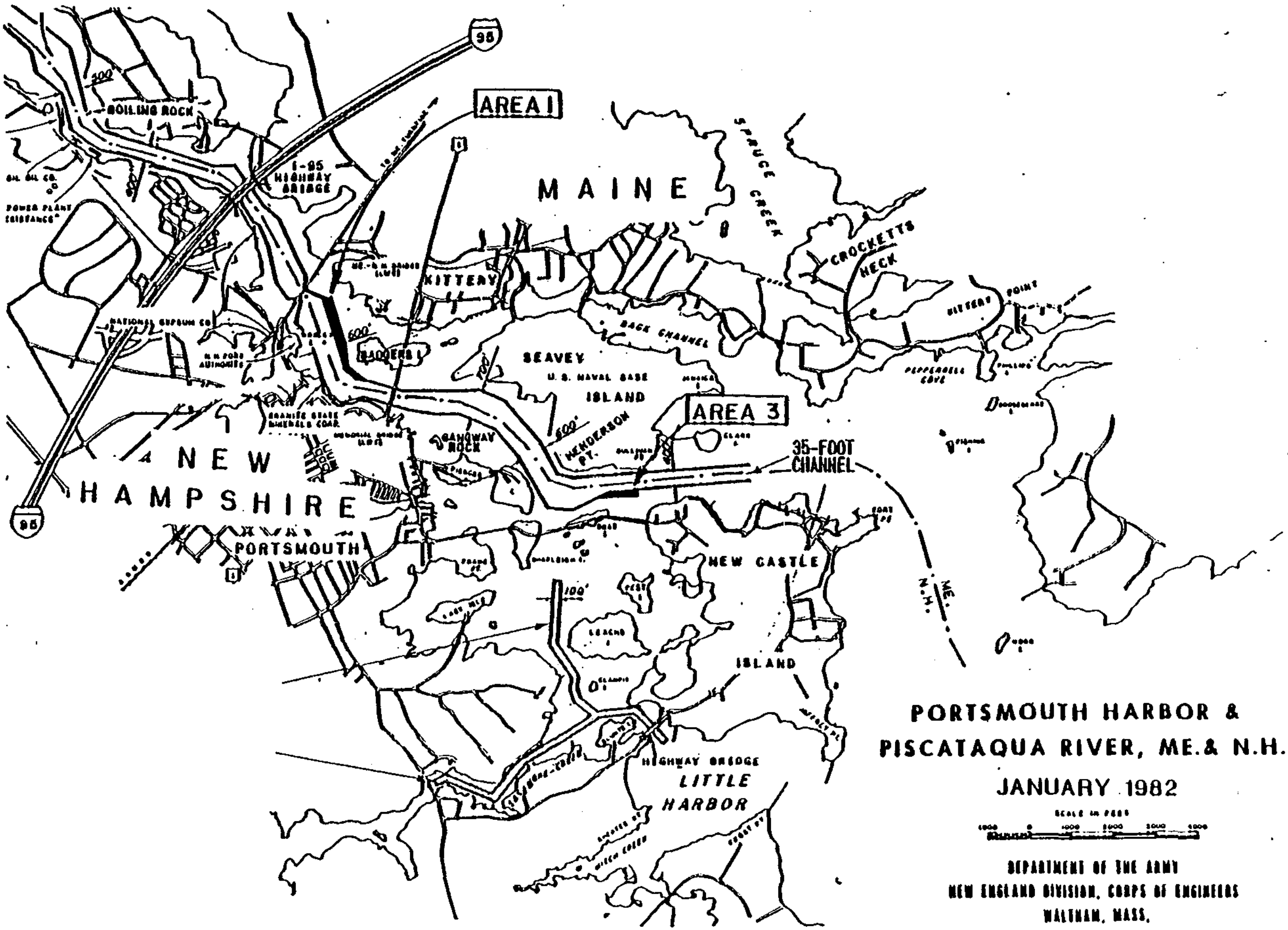

Figure 1. Chart of the Piscataqua River and Portsmouth Harbor Area.
(Source is the U.S. Army Corps of Engineers' Feasibility Report, 1983.)

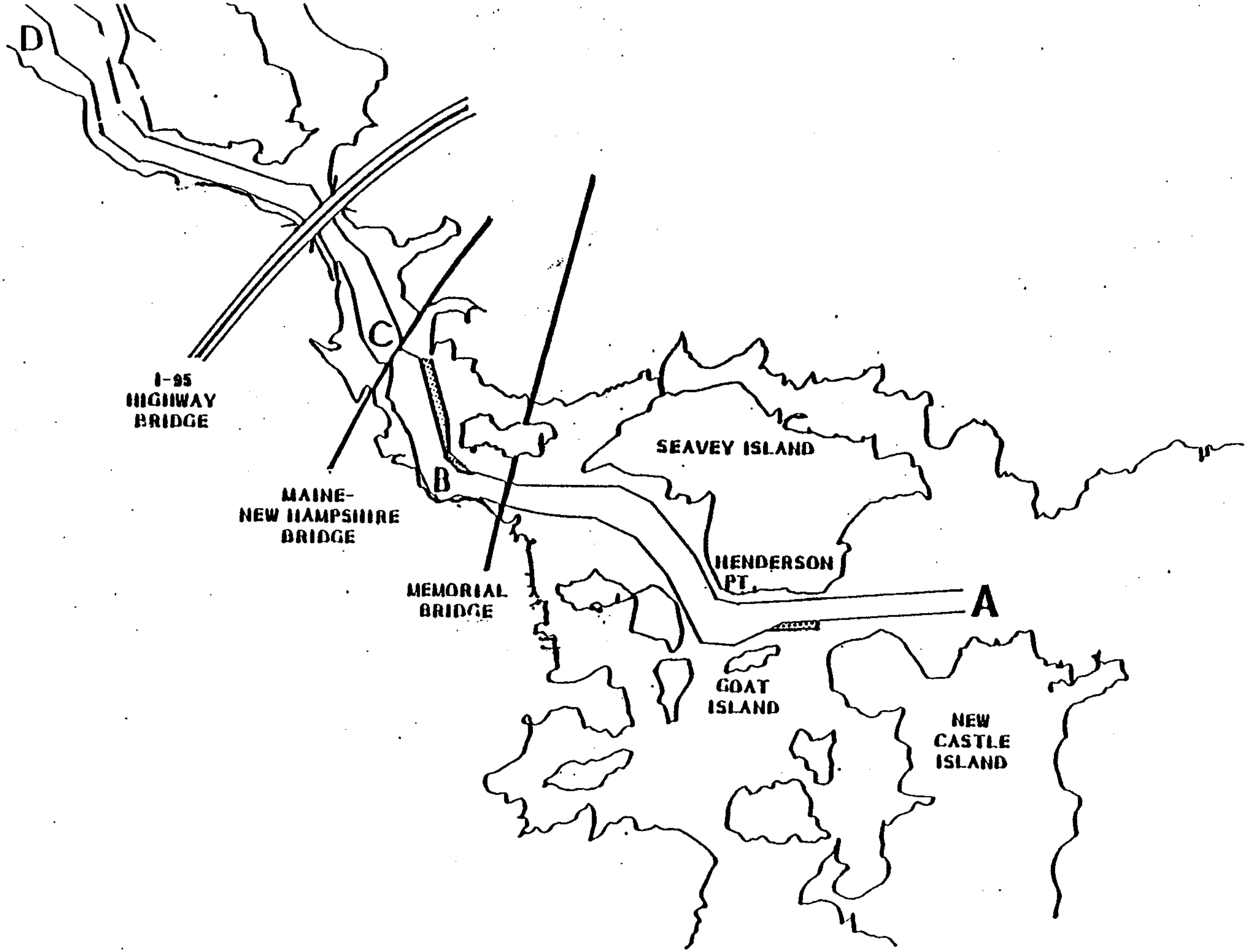

Figure 2. Scenario Chart

APPENDIX C

HYDRODYNAMIC MODEL STUDY

APPENDIX C

GENERAL DESIGN MEMORANDUM

PORTSMOUTH HARBOR NAVIGATION IMPROVEMENT STUDY

HYDRODYNAMIC MODELING

by

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October 1985

WORKING DRAFT

THIS APPENDIX IS CURRENTLY IN THE PROCESS OF BEING FINALIZED. THE FINAL VERSION WILL CONTAIN SUBSTANTIALLY THE SAME INFORMATION AS CONTAINED HEREIN, WITH THE EXCEPTION OF MINOR EDITORIAL CHANGES WHERE DEEMED NECESSARY TO MORE CLEARLY DEFINE THE INFORMATION.

CONTENTS

PORTSMOUTH HARBOR NAVIGATION IMPROVEMENT STUDY

HYDRODYNAMIC MODELING

PART I: INTRODUCTION

Purpose

1. The purpose of this project was to develop and apply a numerical hydrodynamic model of Portsmouth Harbor. Results are to be used by a ship maneuvering simulation study to be conducted at the Computer-Aided Operations Research Facility (CAORF), Department of Transportation. To support the numerical modeling task, a prototype data survey was conducted.

2. The general purpose of the study was to determine the effectiveness of the proposed navigation improvement project in Portsmouth Harbor and the Piscataqua River, New Hampshire. The proposed improvements involve the widening of two bends and a maneuvering area located along the lower portion of the existing 35-ft-deep Federal navigation channel in the Piscataqua River.

Scope

3. A numerical model of the harbor was developed to determine current magnitudes and directions throughout the navigation channel and to predict how these will change in response to proposed channel modifications. The model extends up the Piscataqua River from between Fort Point and Gerrish Island to the vicinity of Frankfort Island.

4. The numerical model was adjusted to reproduce the data collected during a field survey. Then the model was used to simulate the currents and water surface fluctuations during a spring tide for the existing and the improved navigation channel conditions. Model data at selected time steps were provided to CAORF for use in their ship simulation model study.

Portsmouth Harbor and the Piscataqua River

Navigation Facilities

5. Portsmouth Harbor is a 13 mi reach of the Piscataqua River. It is a portion of the boundary between Maine and New Hampshire. Figure 1 is a location map of the area. Most port facilities are located along the river in Portsmouth, New Castle, and Newington on the New Hampshire side. Facilities are also located in Kittery on the Maine side of the river. Petroleum products make up most of the commodities being handled by the harbor.

6. Vessels in the 30,000 to 35,000 dead weight tons (DWT) class are the most frequent size vessel to call on Portsmouth Harbor; however, there has been an increasing trend toward vessels in the 40,000 to 45,000 DWT class (U.S. Army Engineer Division, New England 1983). Lightly loaded vessels in the 60,000 DWT class have been reported by local pilots to have called upon port facilities.

7. Movement of deep-draft vessels through the harbor is made possible by a Federal project that provides for a 35-ft-deep ship channel. The channel is generally 400 ft wide in straight segments and up to 700 ft wide in turns. The trend toward the use of larger vessels in combination with the harzardous physical conditions, including rapid currents, hard bottom material, sharp bands, narrow lift bridges, and restrictive turning areas, prompted the proposed design of improvements to the channel. The proposed improvements include widening the 35-ft-deep channel between the two vertical lift bridges at Portsmouth Harbor from 600 ft up to 1,000 ft (Area 1, Figure 1); widening by 100 ft the northern limit of the channel adjacent to Badgers Island (Area 1, Figure 1); and widening the southern limit of the channel at Goat Island from 400 to 550 ft (Area 3, Figure 1). A second proposed improvement area (Area 2) was eliminated from further study. The larger vessels arrive loaded to drafts of 37 ft and enter the harbor during flood tide to take advantage of the extra depth. They time their transit to start so that they can arrive dockside at slackwater.

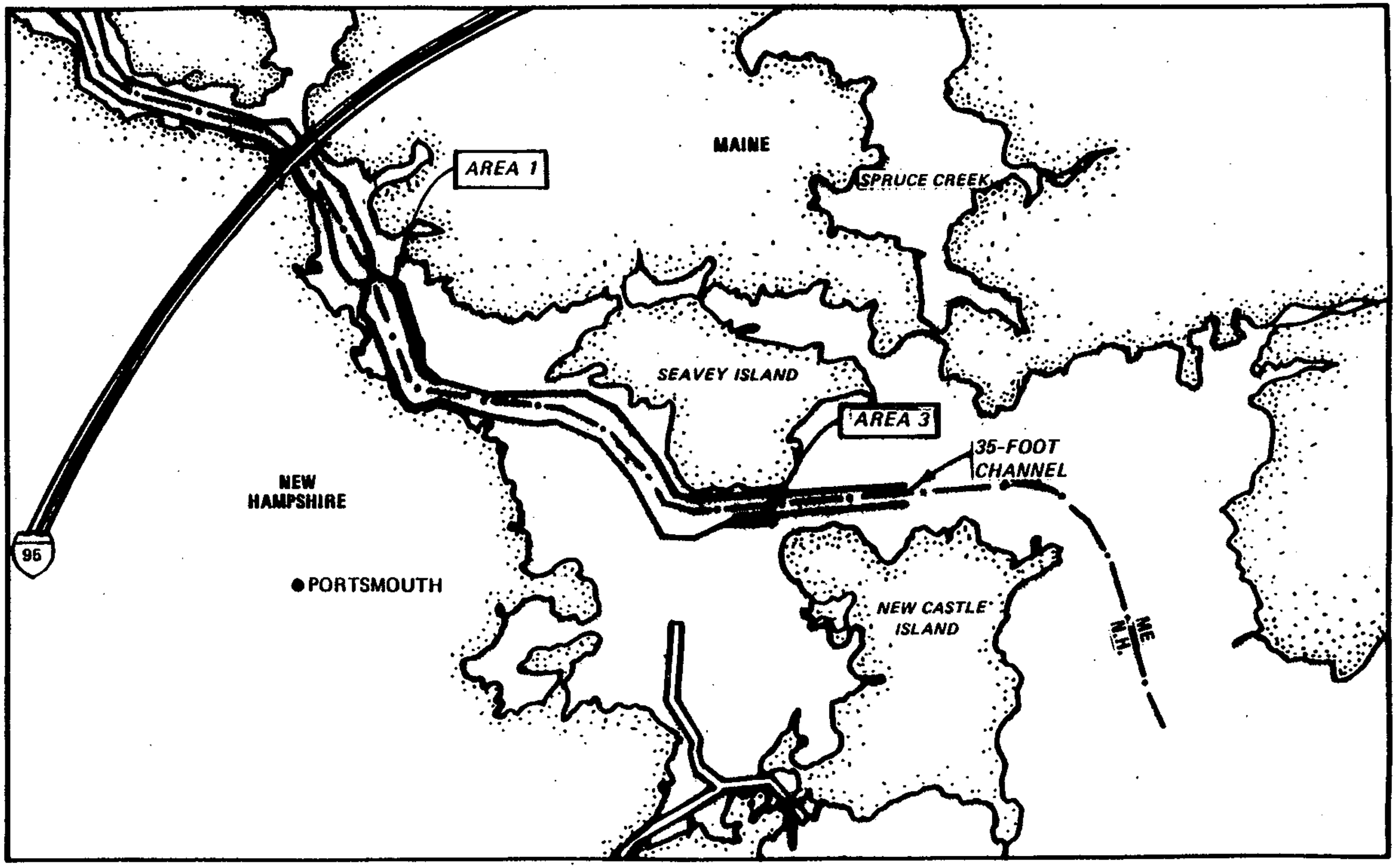


Figure 1. General location map

PART II: PROTOTYPE DATA COLLECTION PROGRAM

Purpose

8. The purpose of the prototype data collection program for this study was to acquire sufficient data to properly prescribe the boundary conditions for the numerical model. Sufficient data were also needed within the study limits to provide a basis to ensure the numerical model was properly verified. Figure 2 shows the location of all prototype stations.

Sequence of Events

9. Tide gages were first installed at four locations. Tide gage 1 was at the upstream model limit and tide gage 4 was at Fort Point. The gages were installed during 8-9 September and remained in place until 26 September. Tide gage 1 recorded on a 15-min interval and the remaining three gages on a 6-min interval. The gages were surveyed by New England Division, Corps of Engineers personnel so they could all be referenced to MLW datum.

10. ENDECO Model 105 recording current meters were used to measure current magnitude and directions on half-hourly intervals. Four meters were installed in the entrance--a set of two (5 and 25 ft above the bottom) on each side of the entrance range at Points A and D, Range R5, Figure 3. They were installed on 8 September and remained in place until 13 September. One meter did not start recording data until 12 September. One of these meters also operated during the period 18-26 September. One string of the meters was lost. Two meters were installed at the upstream boundary and recorded during the period 13-26 September at Points A and E, Range R-1.

11. The prototype data collection program for this study consisted of a 13-hour survey (0600 to 1900 EST) on 12 September. Five ranges (4-5 stations each) plus a single point range (6A) were monitored. Data collected consisted of hourly current speeds/directions and water samples collected at various depths. The water samples were analyzed for salinity. The air temperature on the day of the survey ranged from 55 to 80 deg F with clear skies and a 10 to 15 mph northerly wind.

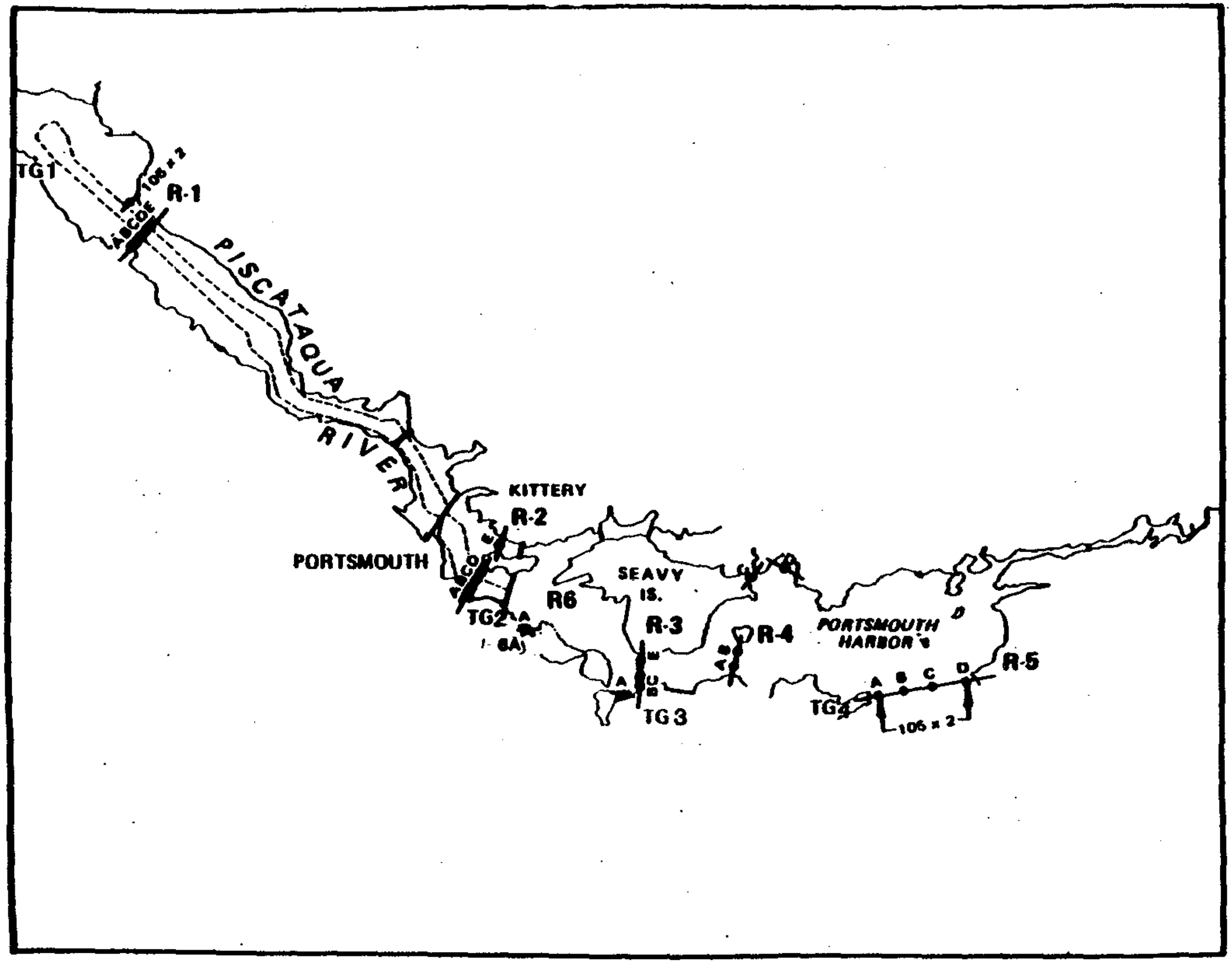


Figure 2. Prototype data station locations

Tidal Information

12. An analysis was made of the predicted tidal ranges over a year at Portsmouth. The source of information for this analysis was the National Ocean Survey (NOS) 1984 Tide Tables - High and Low Water Predictions - East Coast of North and South America. A frequency distribution of this data is shown in Figure 3. This distribution indicates that the 7.3-ft measured tide at the Portsmouth gage on 13 September during the prototype survey was an average condition and the 10.4-ft tide measured on 25 September was exceeded during only 10 percent of the year. This latter condition was used as the spring range for verification.

Tidal Currents

13. Tidal current data for this area were scarce. A 1975 data report from the University of New Hampshire (Swenson, Brown and Trask 1977) was the only source of data located. The two data collection points in our study area were located at or nearby their Portsmouth and Newington stations. The Portsmouth station was between the I-95 bridge and the narrow lift bridge below it, near Range R2, Figure 2. The Newington station was approximately at the upper limit of our numerical model, near Range R1, Figure 2. The data provide some insights into lateral and vertical distributions of currents during a 13-hour period.

14. It was reported by Portsmouth pilots that maximum flood occurs approximately two hours after the maximum tidal rise. This was verified during the analysis of the prototype data.

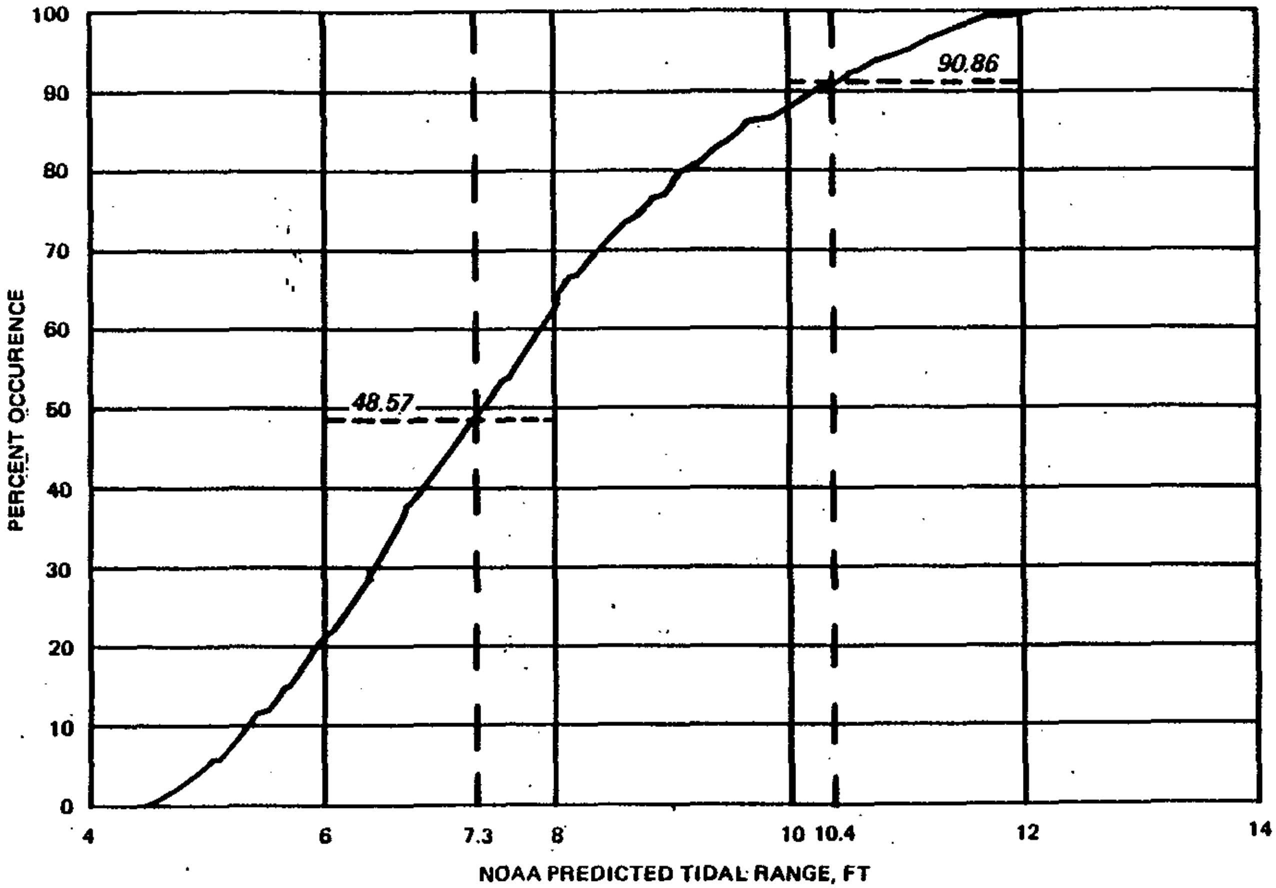


Figure 3. Frequency distribution NOAA predicted tidal range

Results

15. The tidal data taken during the prototype data survey are shown on Figure 4. There was very little phase change in the study area between stations 2-4. The tidal range changed from 7.94 ft at station 4 to 7.30 ft at station 2.

16. The velocity data from the various ranges are shown on Figures 5-12. These data were vertically averaged for comparison with the numerical model results. Largest flood velocities were observed at stations 2C and 3E. The data were plotted as taken with no smoothing. It should be noted that the tidal current phasing at station 6A was opposite that at station 3A. These two stations bordered into a marshy area that drained and flooded during the tidal cycle; therefore, it appears that water flows through the marshy area.

17. The tidal data taken on 25 September 1984 is shown on Figure 13. As noted above, there was very little phase change in the study area between station 2-4. The tidal range changed from 11.75 ft at station 4 to 10.38 ft at station 2.

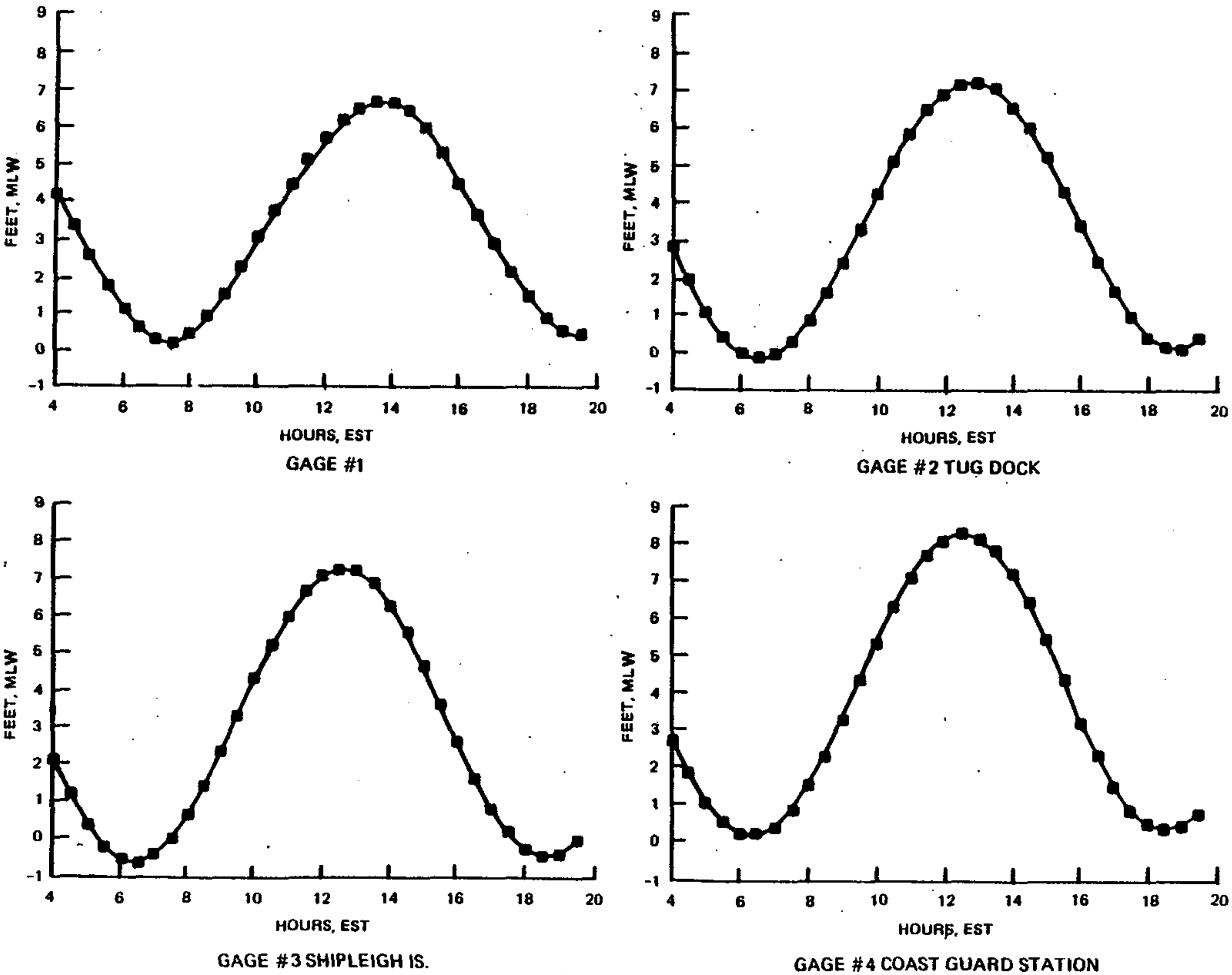


Figure 4. Tidal data - prototype survey

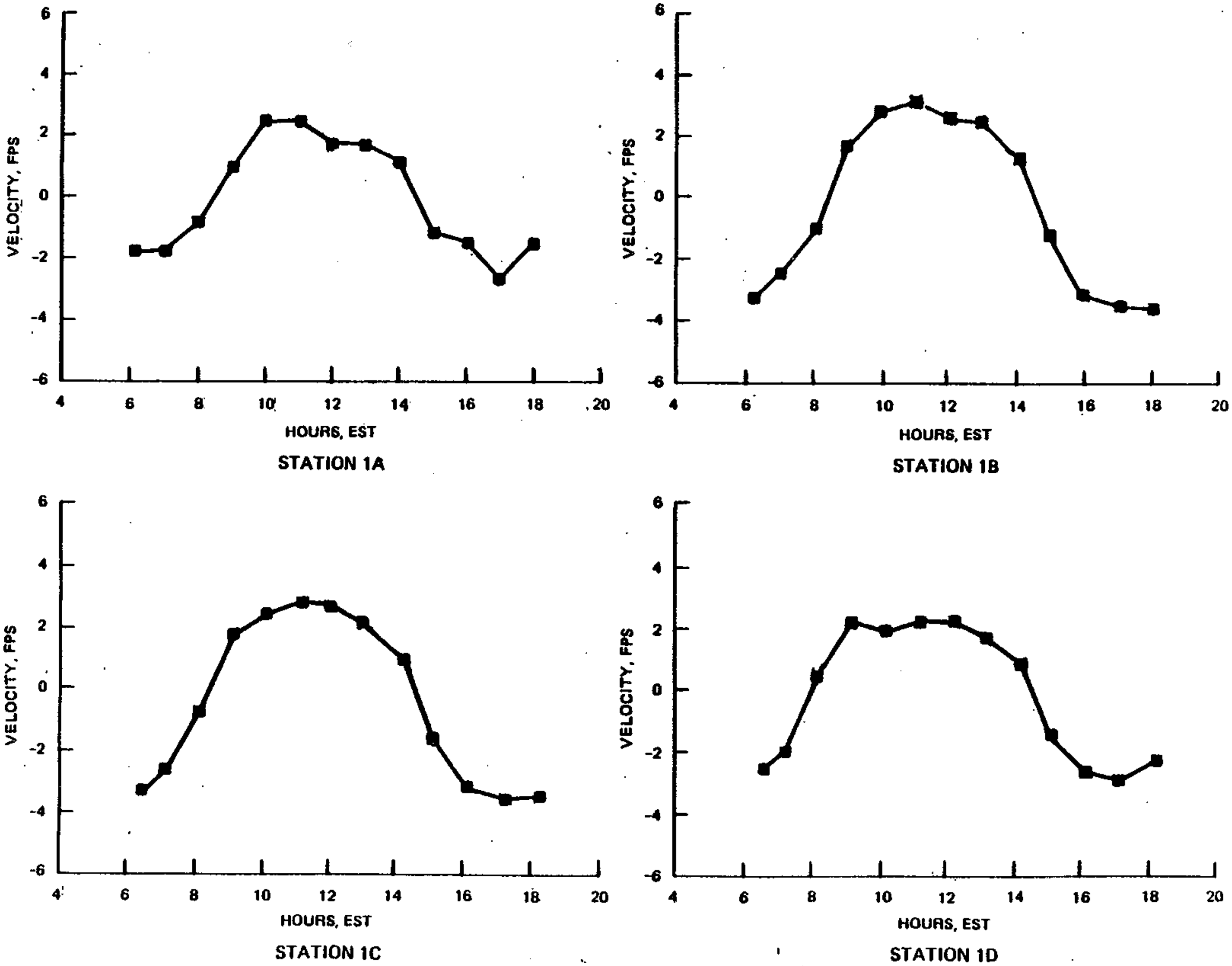


Figure 5. Range 1 - vertically averaged velocity plots

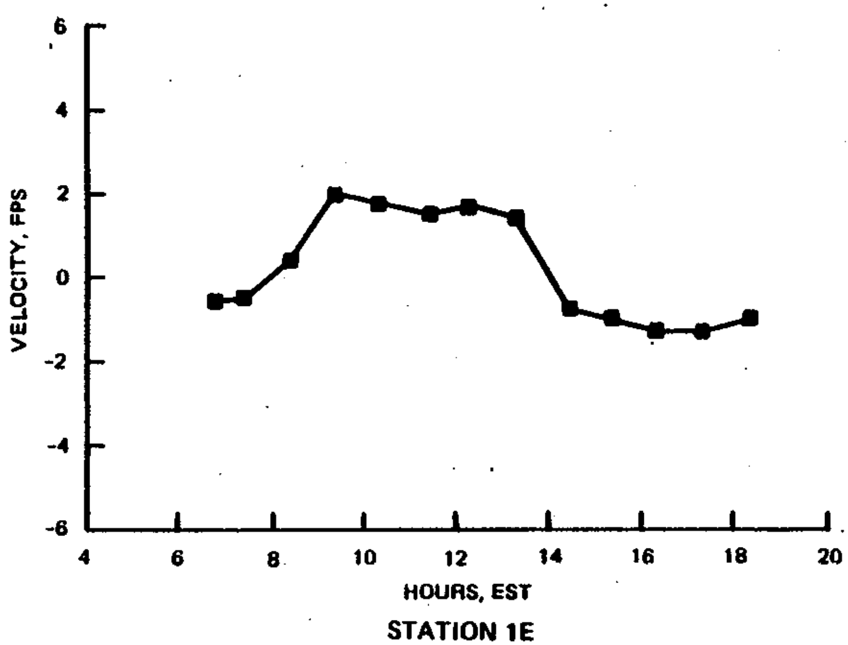


Figure 6. Range 1 - vertically averaged velocity plots

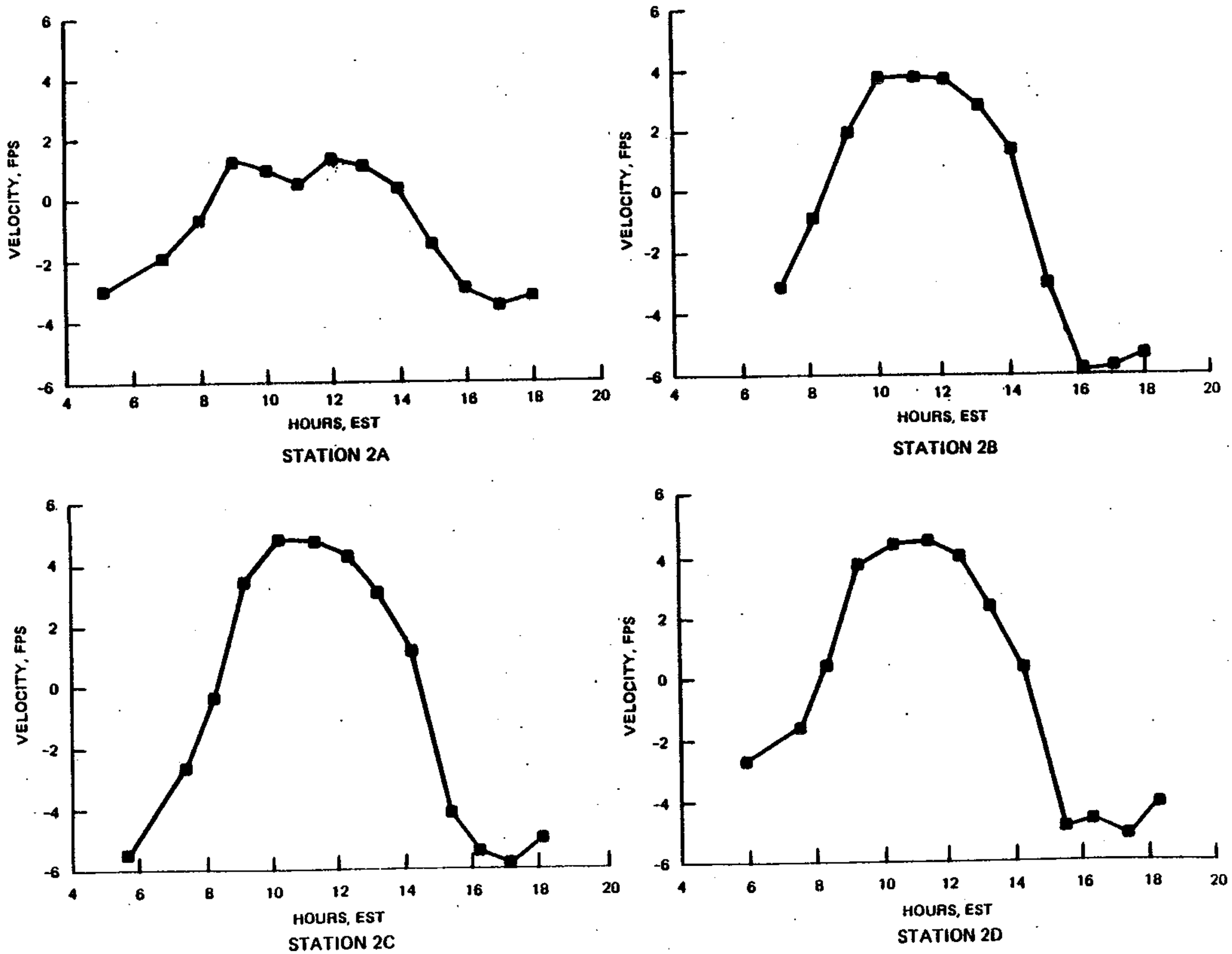


Figure 7. Range 2 - vertically averaged velocity plots

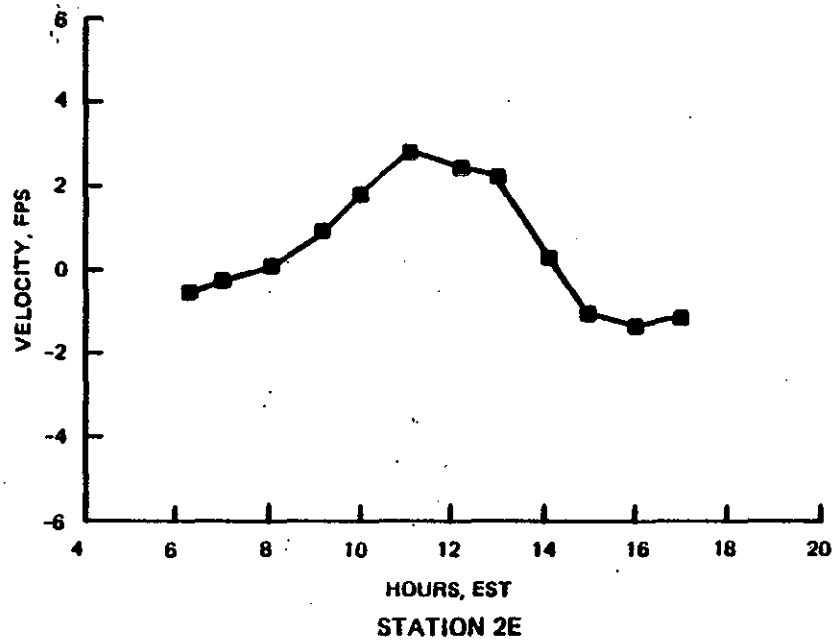


Figure 8. Range 2 - vertically averaged velocity plots

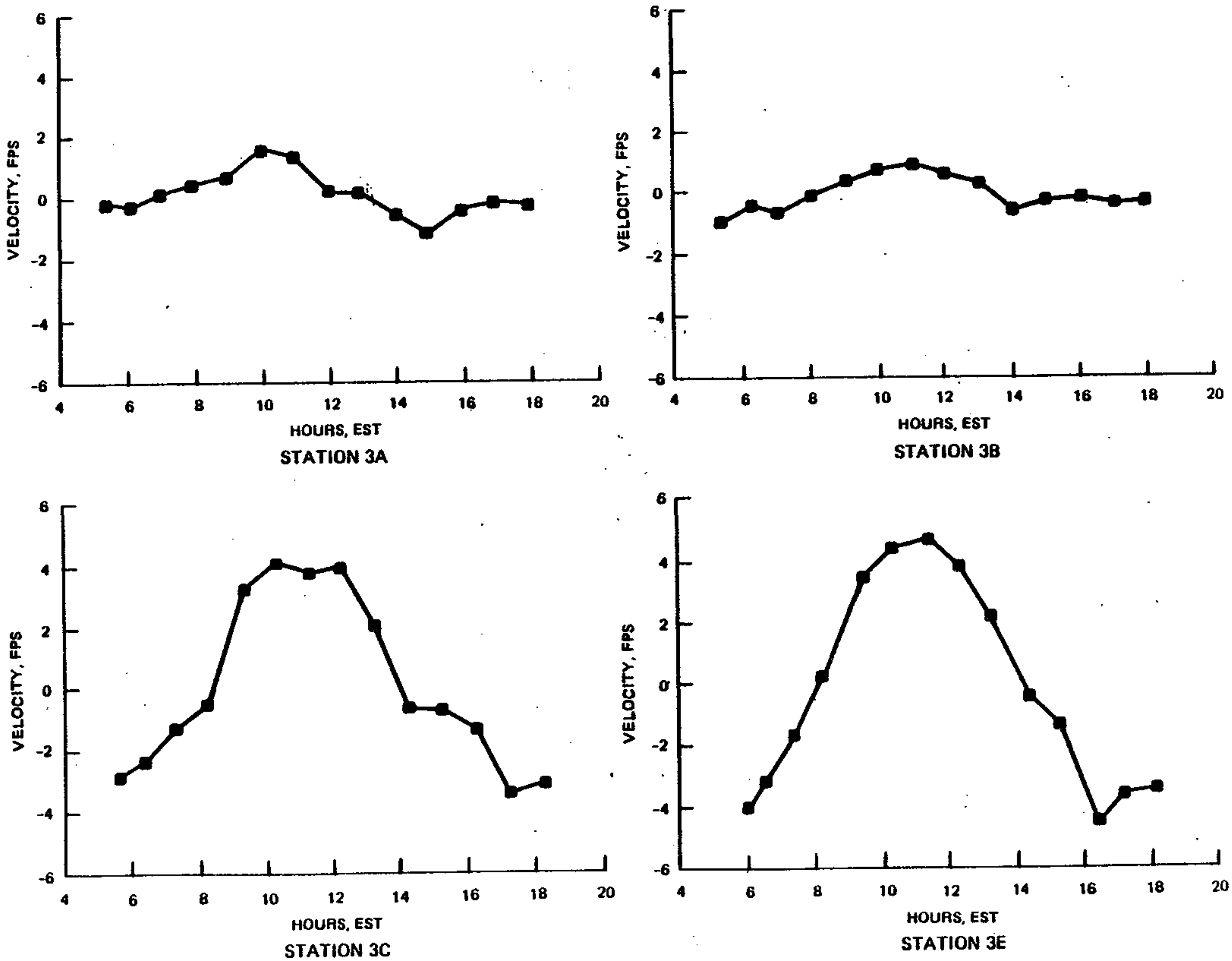


Figure 9. Range 3 - vertically averaged velocity plots

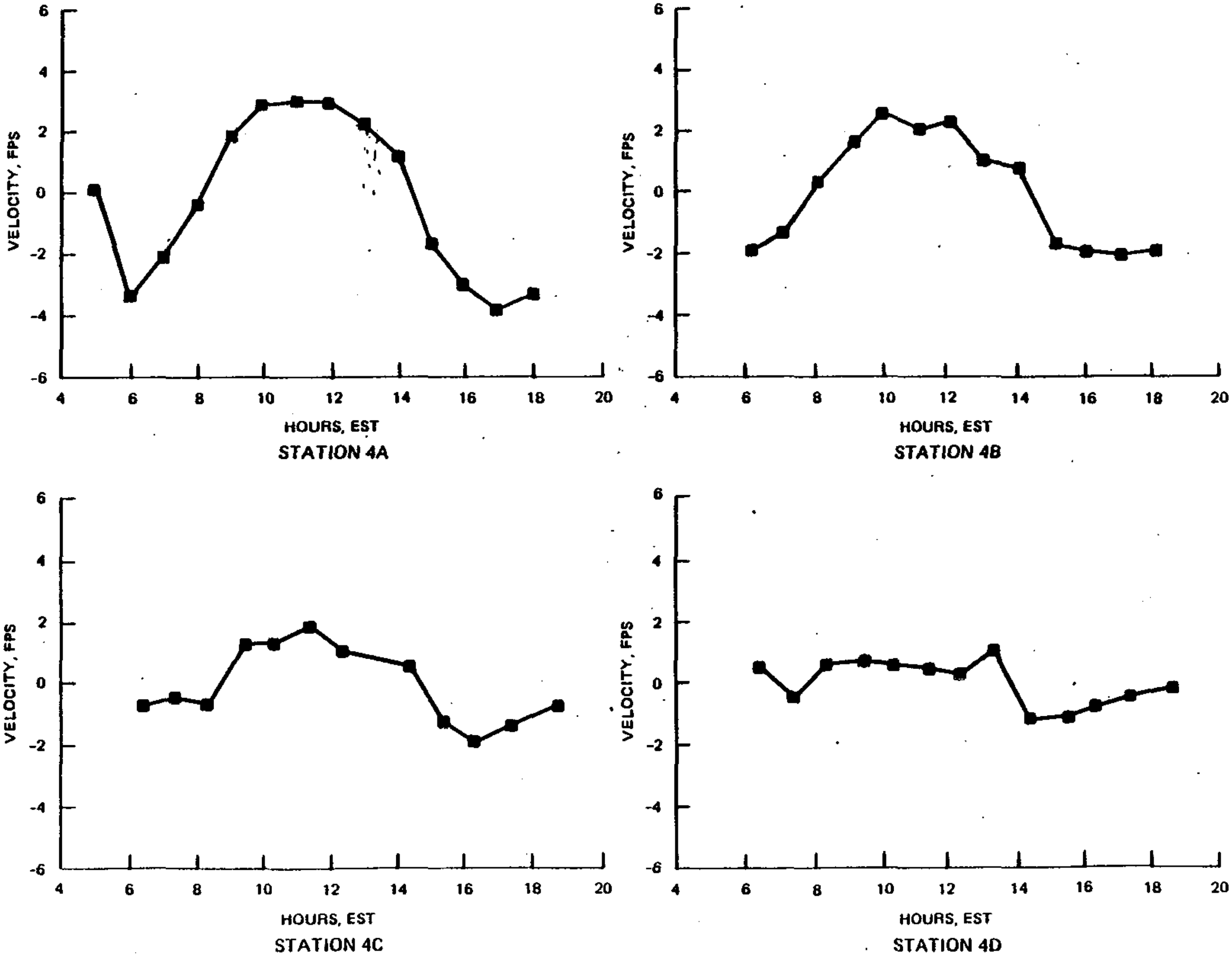


Figure 10. Range 4 - vertically averaged velocity plots

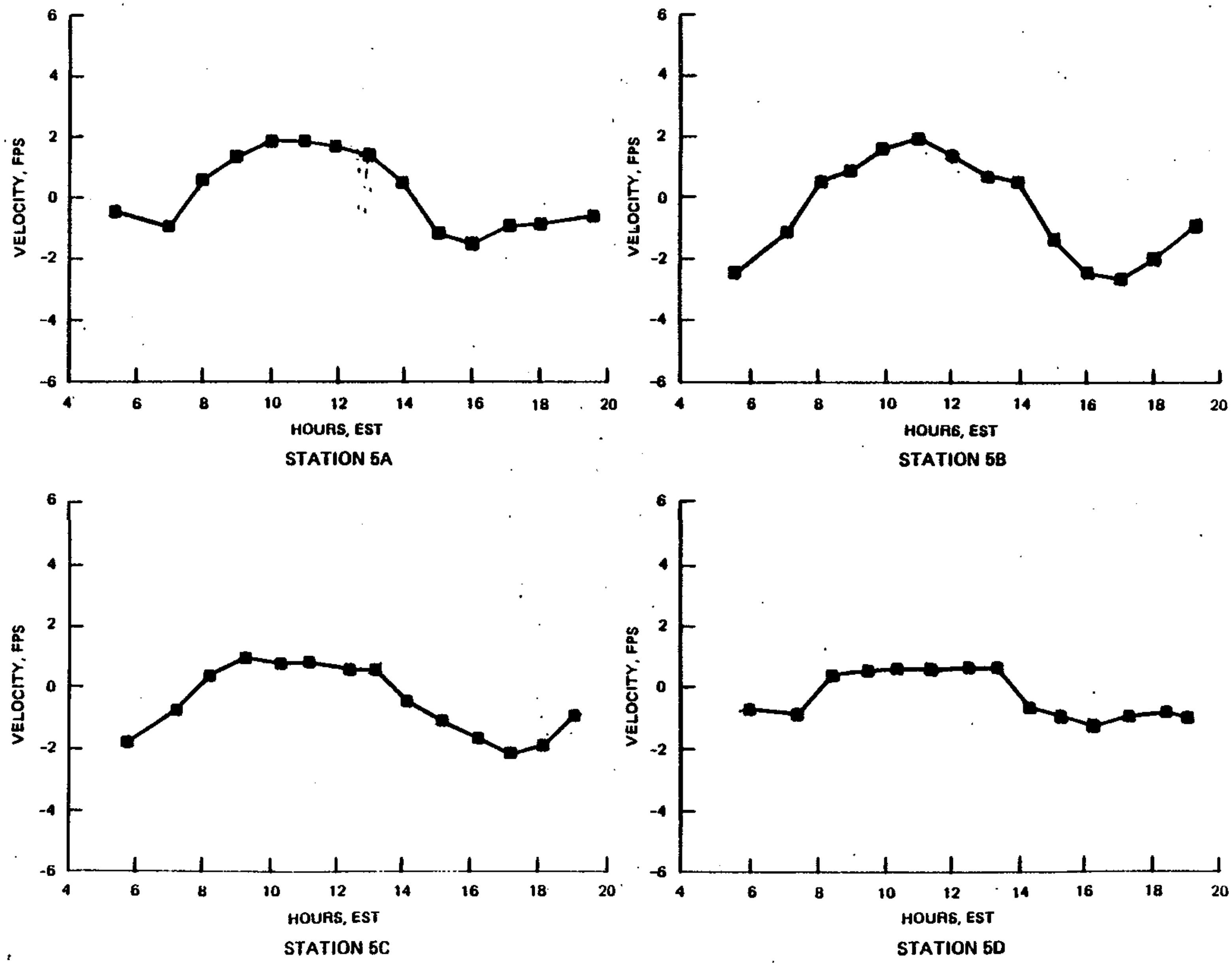


Figure 11. Range 5 - vertically averaged velocity plots

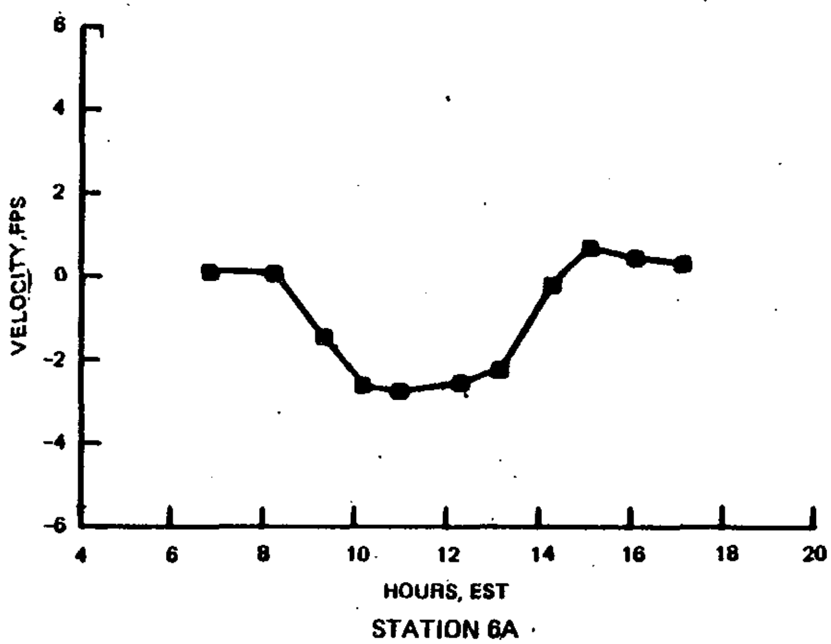
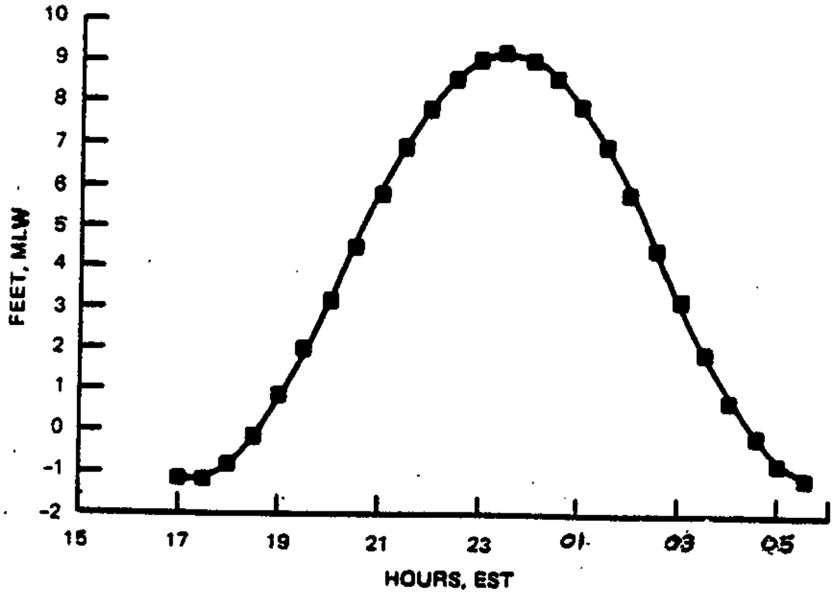
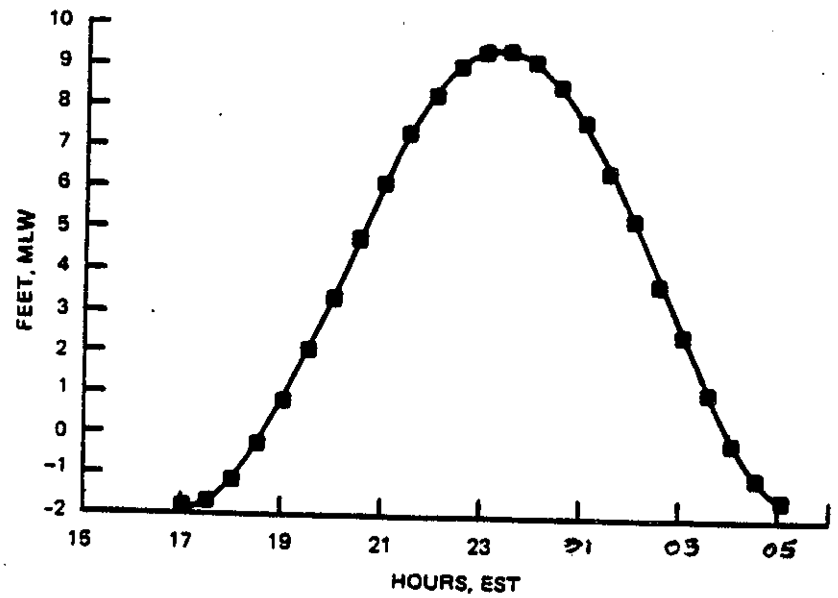


Figure 12. Range 6 - vertically averaged velocity plots



GAGE #2 TUG DOCK



GAGE #3 SHAPLEIGH IS

Figure 13. Tidal data - September 25

PART III: THE NUMERICAL MODEL

(This section is from the TABS-2 Users Manual)

Finite Element Mesh Generation

18. The finite element model RMA-2V requires that a representation of the area to be studied be put in a usable form. This representation is in the form of a set of computational points that have been located with respect to a reference system. These computational points are assigned a sequential number and a bed elevation. These computational points are called nodes. The nodes are connected to each other by lines that create either triangular or quadrilateral elements. The nodes midway between corners are called midside nodes.

Hydrodynamic Model, RMA-2V

19. The hydrodynamic model, RMA-2V, solves the depth-integrated equations of conservation of mass and momentum in two horizontal directions. The present model is an improvement of an earlier version, RMA-2 (Norton and King 1977).

20. The finite element method and method of weighted residuals are used to solve the conservation of mass and momentum equations. The shape functions are quadratic for flow and linear for depth. Integration in space is Gaussian. Derivatives in time are replaced by nonlinear finite difference approximations.

21. The finite element solution is fully implicit and a set of simultaneous equations is solved by Newton-Raphson iteration. The solution is achieved using a front-type matrix inversion that assembles a portion of the matrix and solves that portion before assembling the next portion of the matrix. The front solver's efficiency is largely independent of band width and thus does not require as much care in formation of the computational mesh as do traditional solvers.

PART IV: MODELING PROCEDURE

Development of the Numerical Model Mesh

22. The limits of the numerical model mesh for this study were bounded by a line drawn from between Fort Point and Gerrish Island at its downstream boundary and extended upstream to the vicinity of Frankfort Island. The final grid contained 1,710 nodes and 516 elements. Figure 14 shows the completed numerical mesh for this study.

23. Two National Ocean Service (NOS) charts were used in the mesh development--NOS Charts 13283 Cape Neddick Harbor to Isles of Shoals (scale 1:20,000) and Portsmouth Harbor (scale 1:10,000) and 13285 Portsmouth to Dover and Exeter (scale 1:20,000). NED supplied condition survey sheets dated May 1984 showing depths in the channel from Clark Island to the upstream model boundary. The NOS charts were used to determine appropriate depths in those areas not covered by the division surveys. The division survey sheets were contoured to easily define depth variations and so the mesh could be designed to follow these contours where appropriate.

24. Nodal depths were not always fixed by bathymetry since some of the elements covered large variations in depth. In these cases, a depth was chosen to obtain proper cross-sectional area.

25. The coordinates at all nodes were based on the local state grid coordinate system. The grid was located on NOS charts.

Development of Boundary Data

26. The numerical model boundary control data for this model were developed from data collected during the prototype survey.

27. The appropriate boundary conditions to apply at the upstream and the other three boundaries at Pierces, Shapleigh Islands, and Spruce Creek were velocities. At the ocean entrance water surface elevations were prescribed.

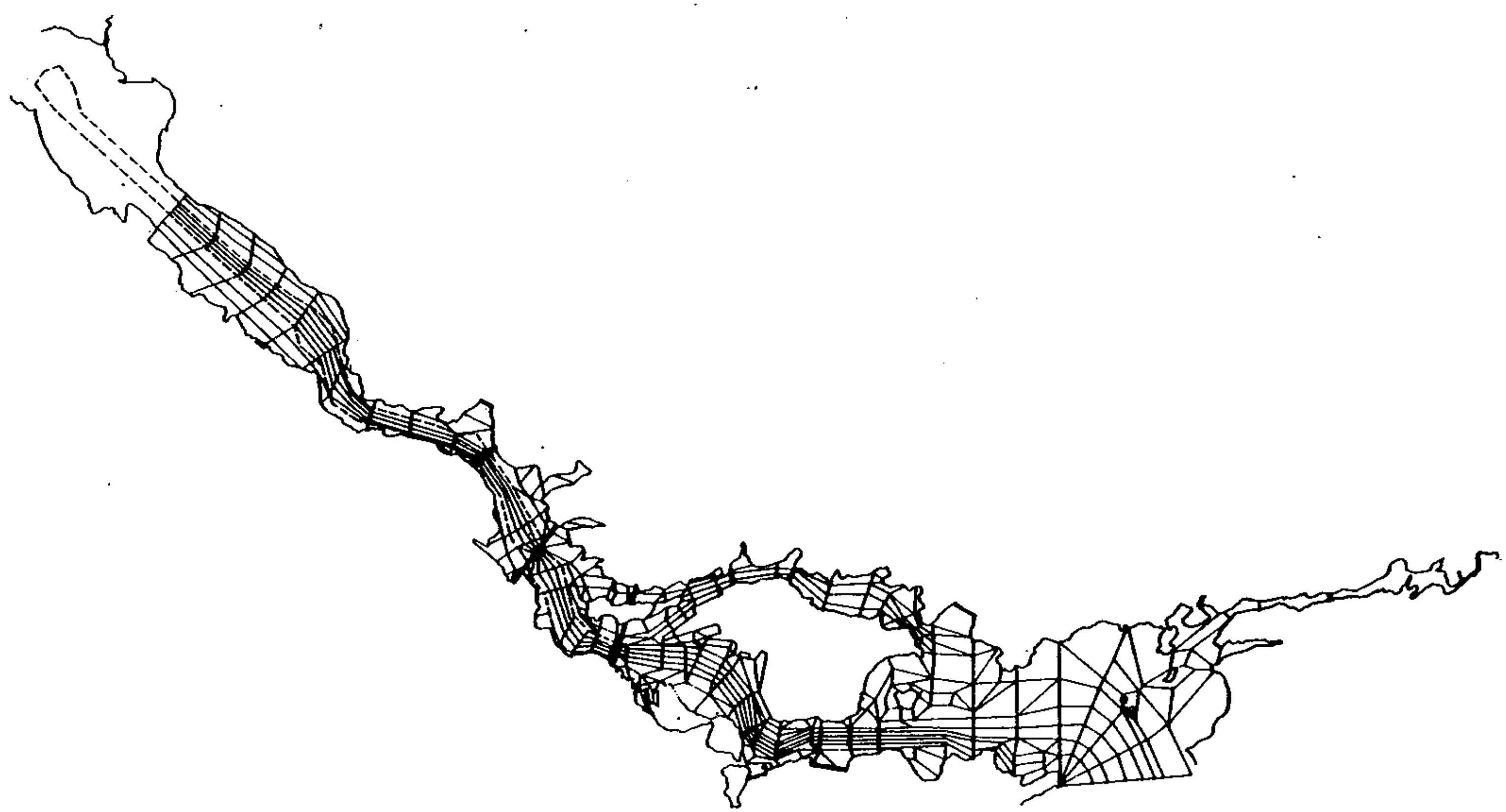


Figure 14. Portsmouth harbor - numerical model mesh

28. The tidal data were adjusted to the mean low water (MLW) datum. The velocity data had to be depth averaged before they could be used as boundary data.

Model Adjustment

Adjustment procedure

29. The numerical model was adjusted until tidal range and phasing compared satisfactorily with prototype observations. This included the tidal data at the upstream boundary were included in these comparisons. Then velocities were compared and further adjustments made until there was reasonable agreement. One hour time steps were used.

Comparison of numerical model results - adjustment

30. There were 12 stations for comparison with the numerical model results. Velocity data were collected at nine of these and tidal data at three. These comparisons are needed to ensure the numerical model is calculating an accurate representation of the vertically averaged currents and tidal elevations. Figures 15-18 are the prototype/numerical model comparisons.

31. The comparisons confirm the numerical model's ability to reproduce proper currents and surface elevations. The comparisons indicate that the phasing of the tide is excellent. The magnitude of velocity also shows very good agreement. Results confirm the validity of the depths selected and the Mannings "n" values chosen.

Model Verification - Base Conditions

Verification procedure

32. The verification of the adjusted model was conducted to ensure that the model could accurately reproduce a condition other than the one to which it had been adjusted. For verification, the numerical model was run with a spring tide at the entrance and modified velocity boundary conditions.

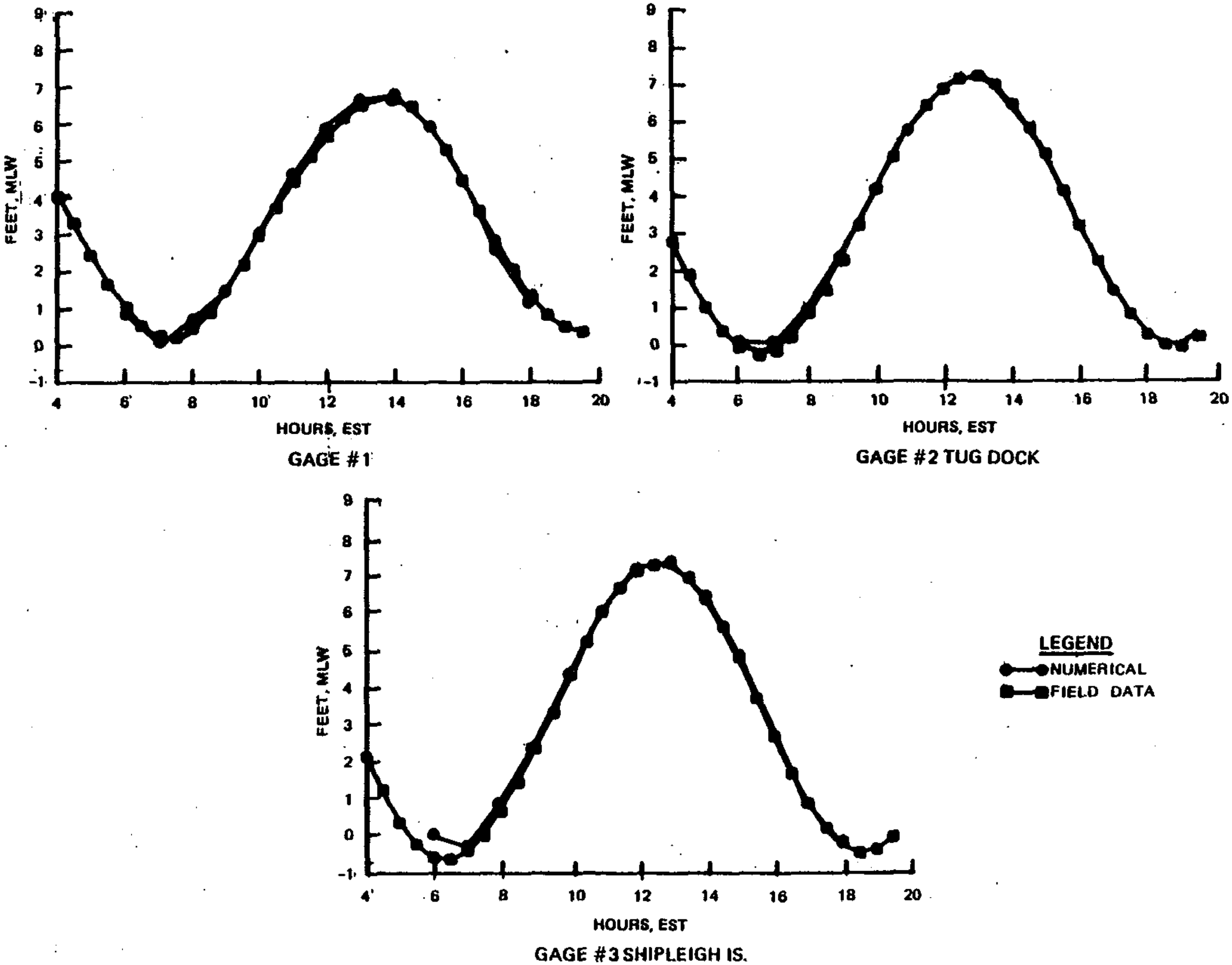


Figure 15. Tidal data - numerical/prototype comparisons - adjustment

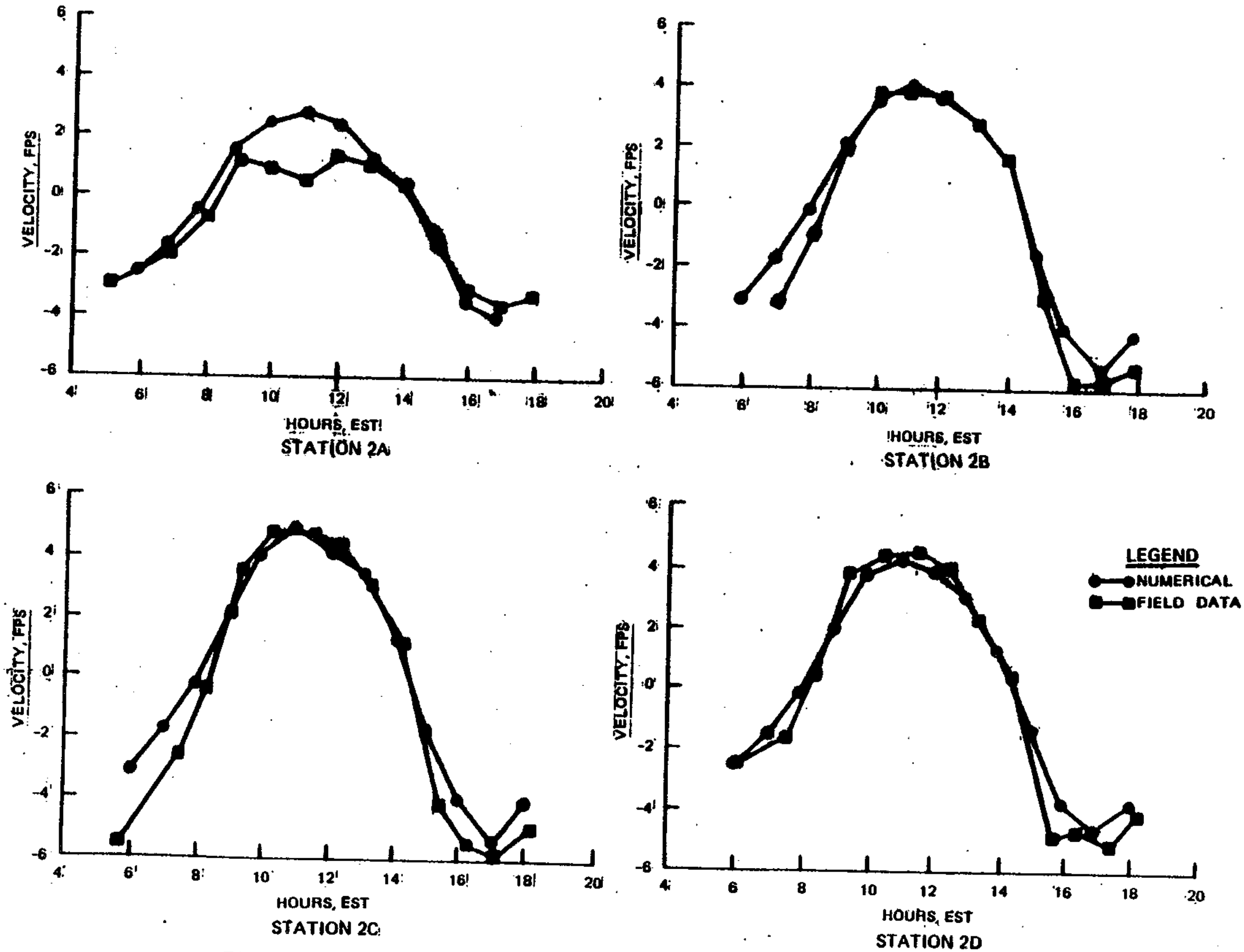


Figure 16. Range 2 - numerical/prototype comparisons - adjustment

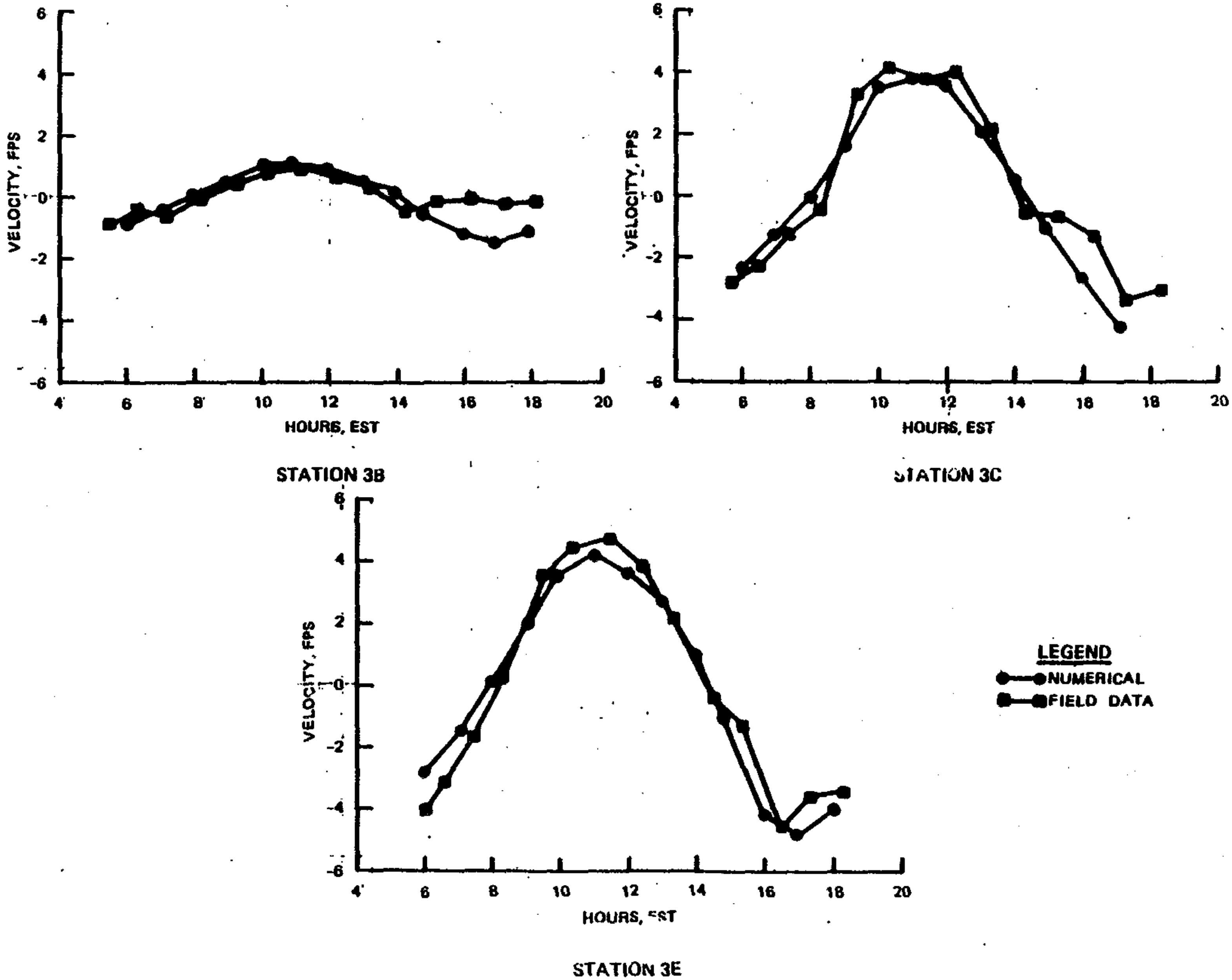
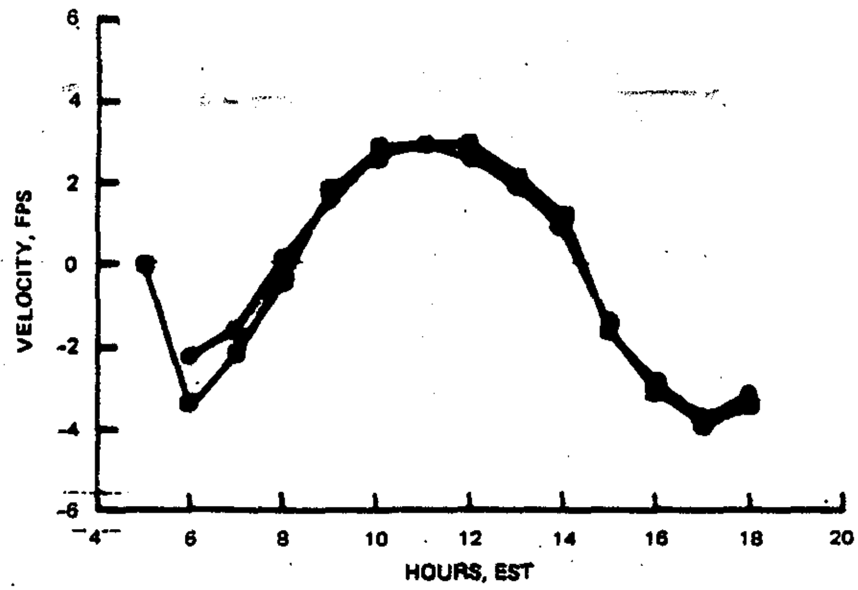
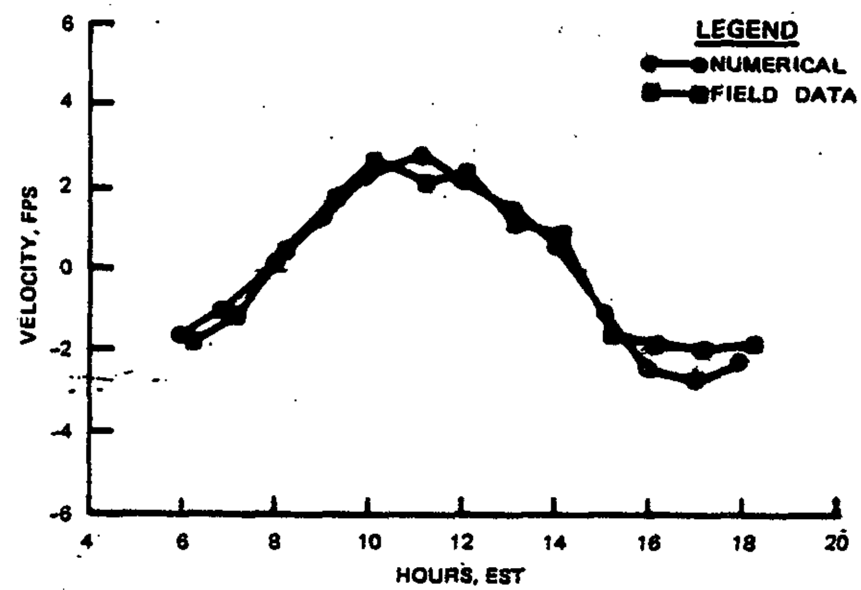


Figure 17. Range 3 - numerical/prototype comparisons - adjustment



STATION 4A



STATION 4B

Figure 18. Range 4 - numerical/prototype comparisons - adjustment

Comparison of numerical model results - verifications

33. There were two stations for comparison with the numerical model results. Figure 19 is a plot of these data. Station 2 compared reasonably well with the exception of the last several hours of the tidal cycle. The phasing was excellent. Station 3 appeared to be about 0.2 ft above the observed data. It is reasonable to assume that the velocities predicted by the numerical model were correct although there were no velocity data to confirm this.

Plan Test

34. The grid was modified as shown in Figure 20. The changes consisted of depth modifications at nodes in the area of proposed channel modifications. The same boundary conditions were used for the plan test as were used for verification (base test).

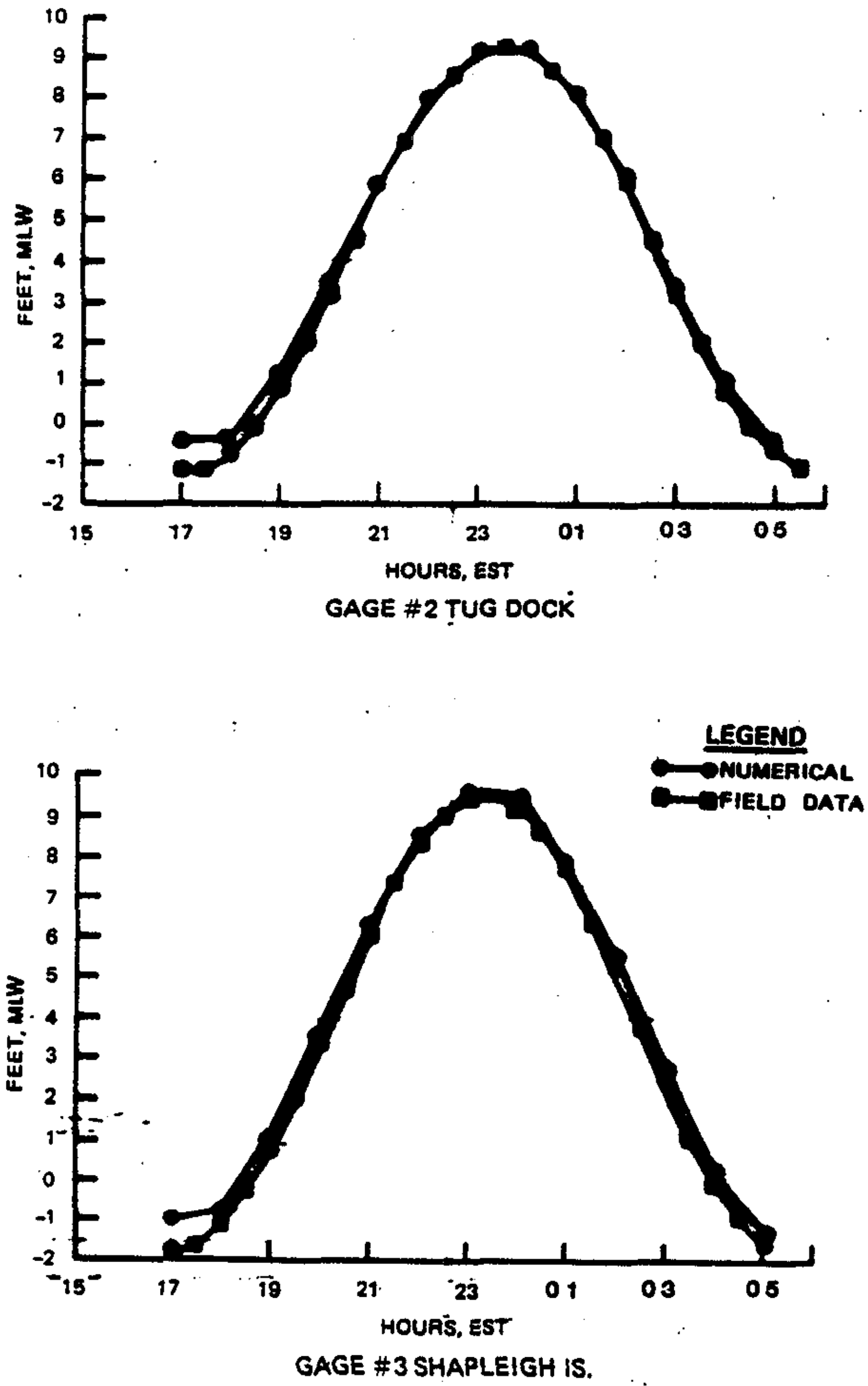


Figure 19. Tidal data - numerical/prototype comparisons - verification

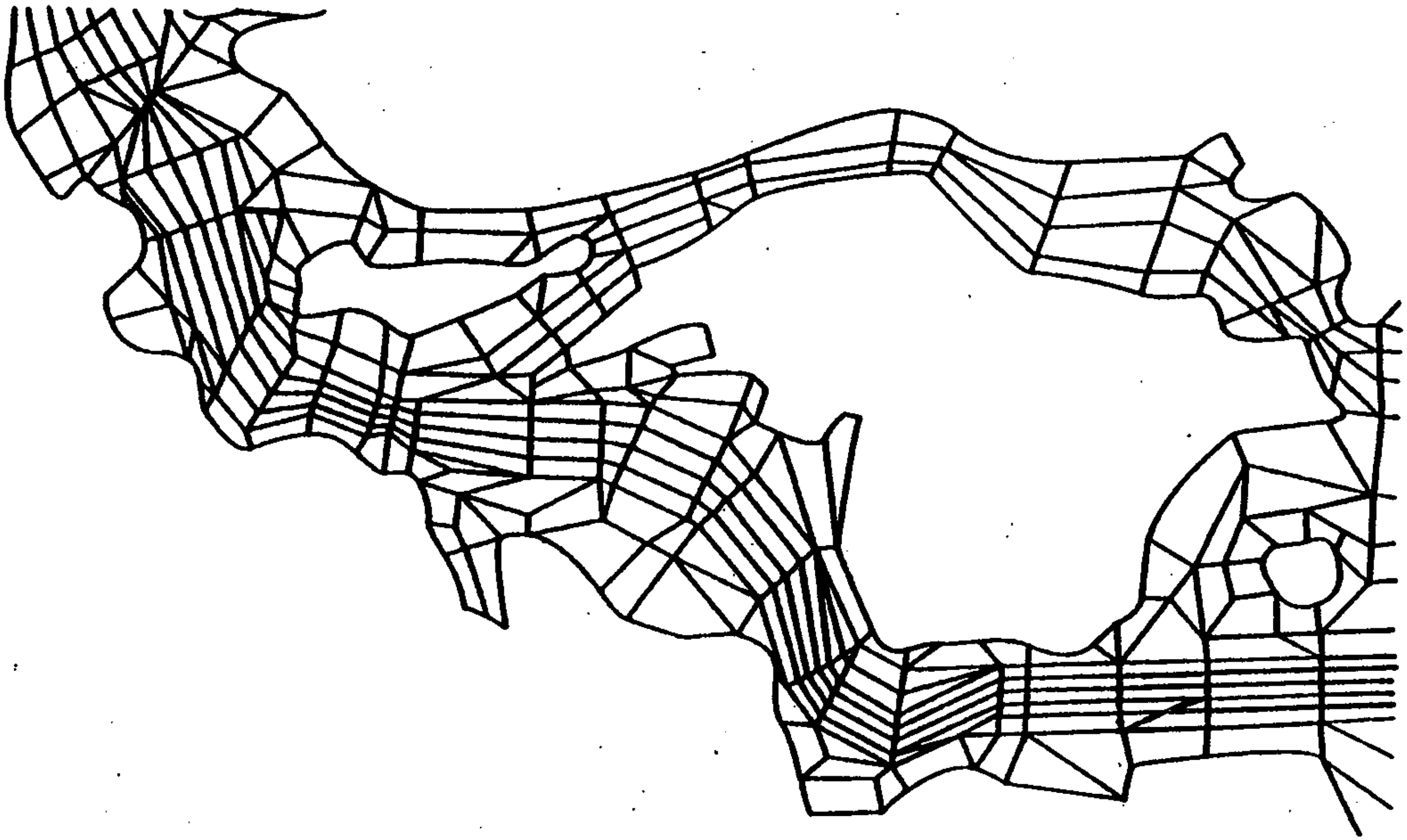


Figure 20. Grid modifications for plan

PART V: RESULTS AND SUMMARY

35. A plot of the data provided CAORF is shown in Figures 21-24. Velocities provided CAORF were taken at 1 hr and 30 min before slack water following flood, i.e., hours 7.5 and 8.0 in the model tidal cycle. The results in general indicate a reduction in current magnitudes within the enlarged channel areas. These areas were expanded, therefore causing reductions in current velocities. Reduced velocities were also noticed in nodes adjacent to these expansions. There is also some change noticed in the directions of these currents.

36. Channel and maneuvering conditions appeared to be improved with the plan changes since the velocities were generally reduced. These changes were all changes that would be expected to have a positive effect on navigation.

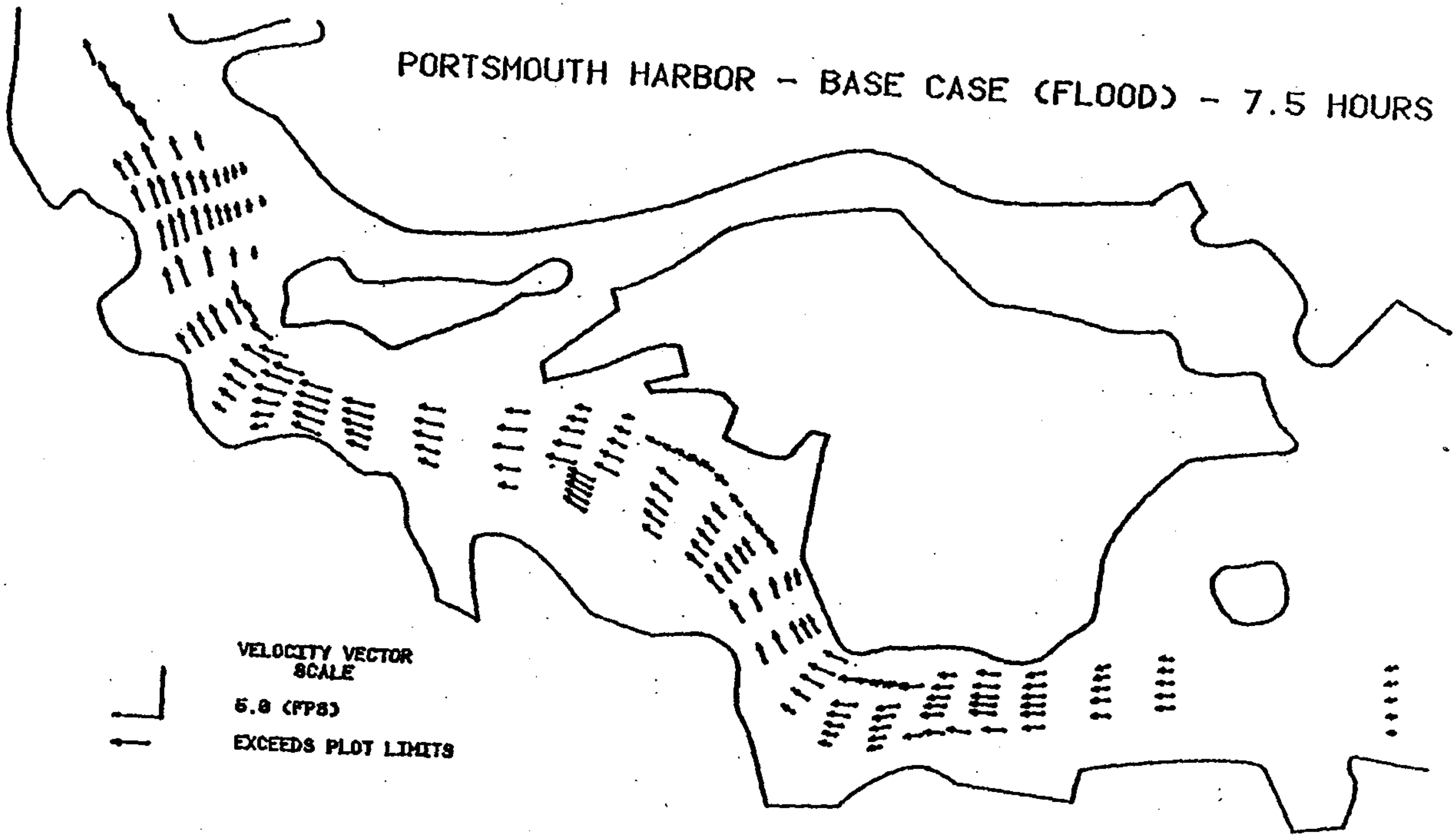


Figure 21. Portsmouth harbor - Base case (flood) - 7.5 hours

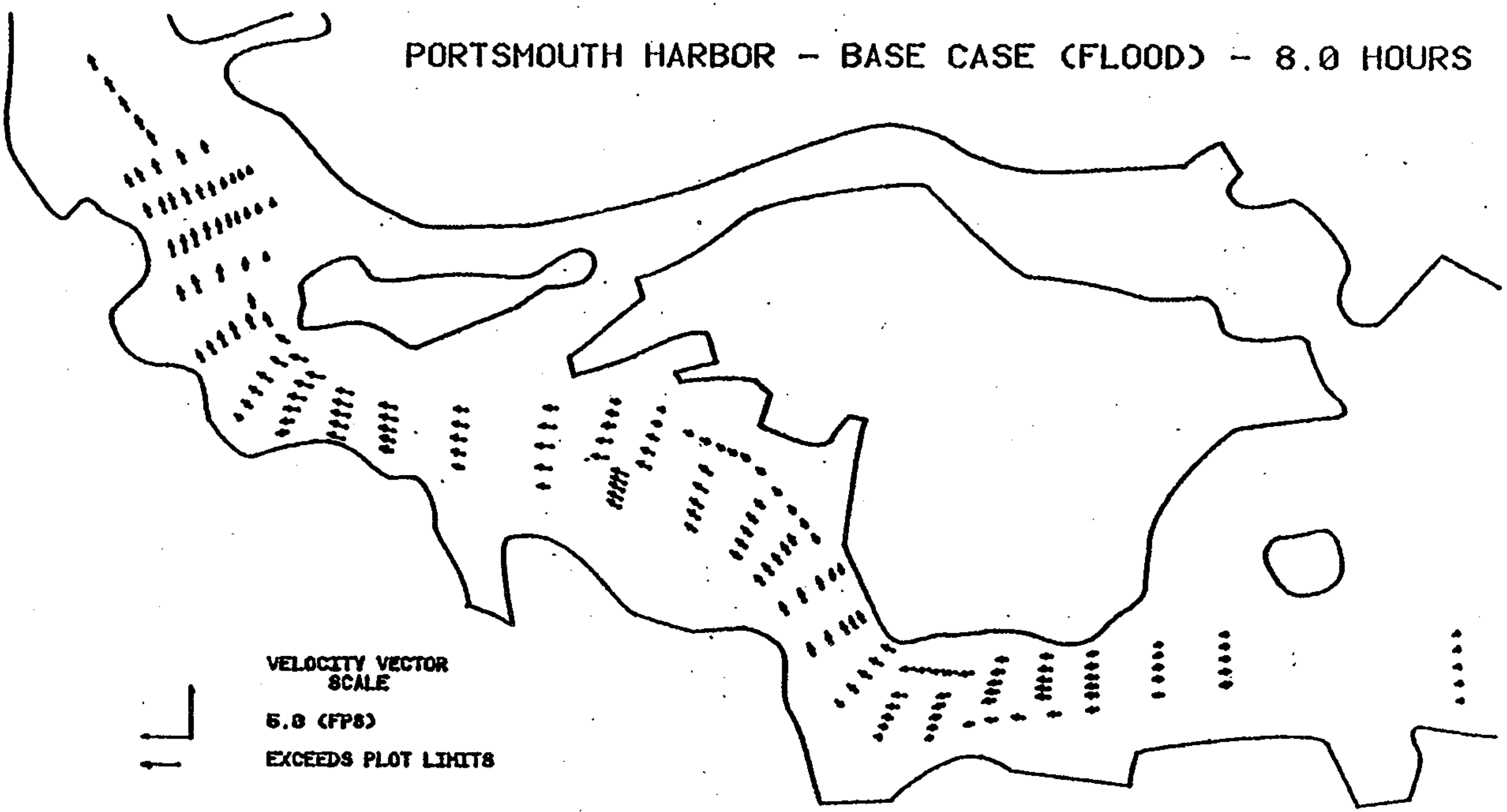


Figure 22. Portsmouth harbor - base case (flood) - 8.0 hours

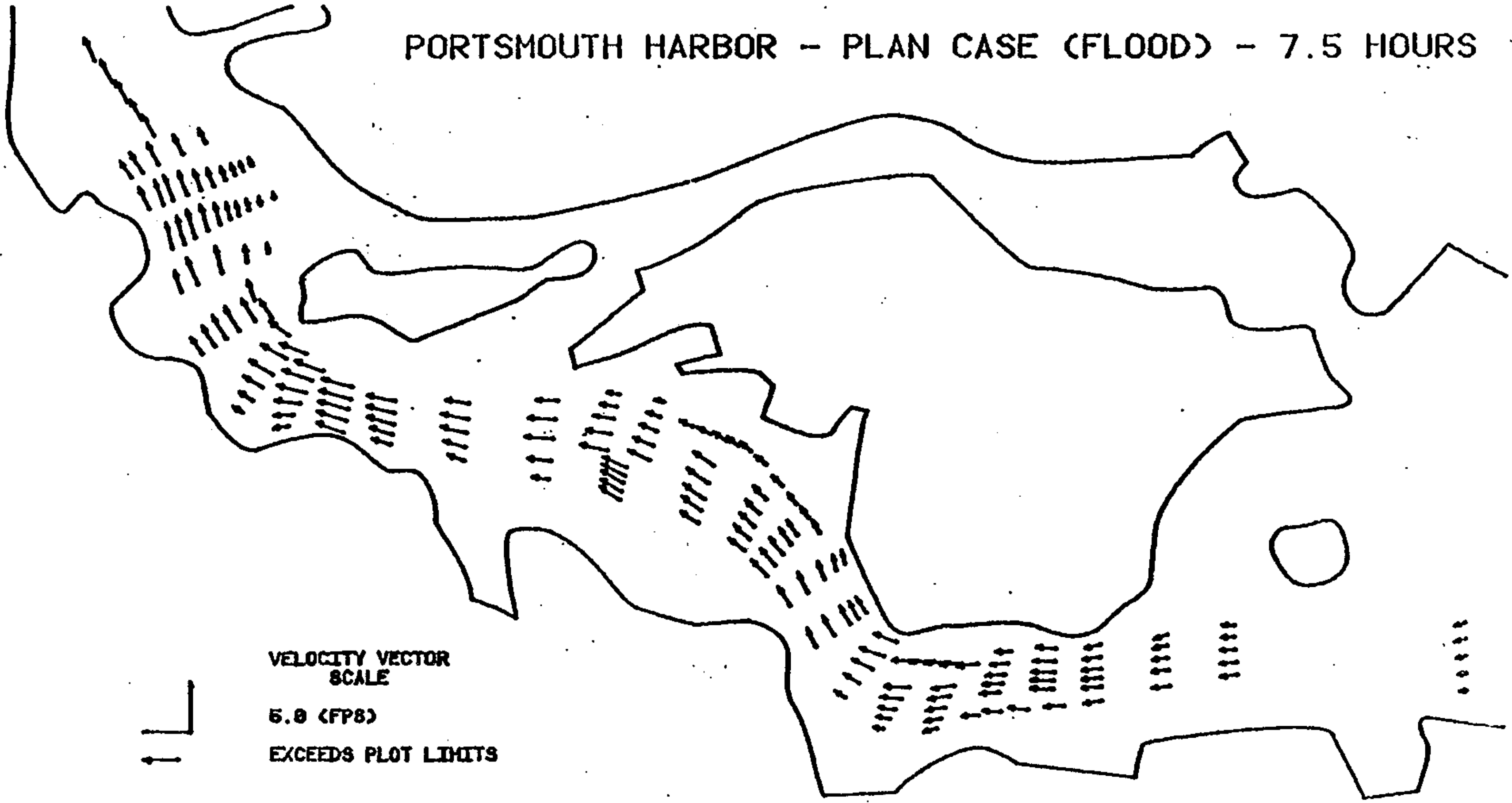


Figure 23. Portsmouth harbor - plan case (flood) - 7.5 hours

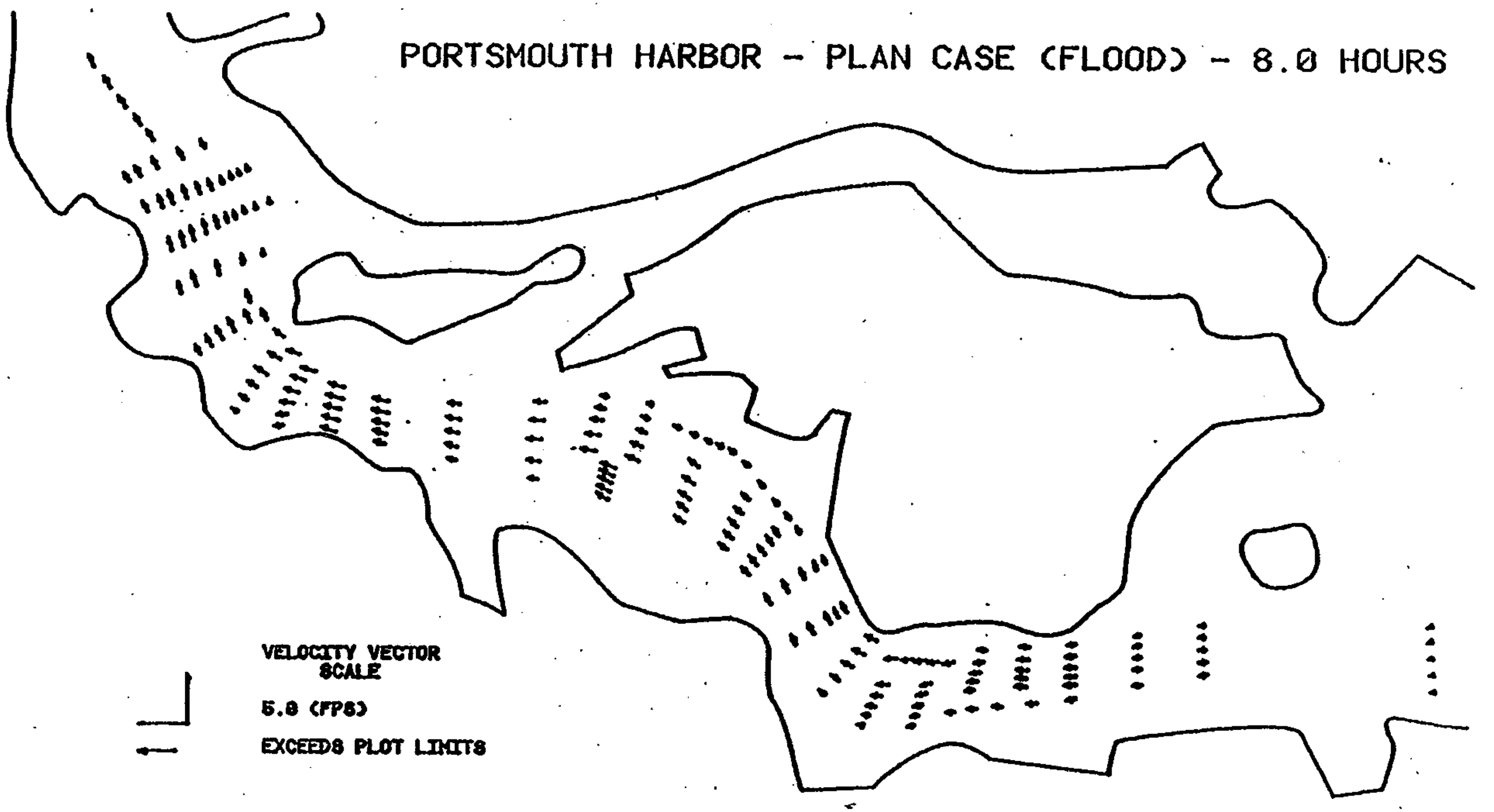


Figure 24. Portsmouth harbor - plan case (flood) - 8.0 hours

APPENDIX D

ECONOMIC ANALYSIS

PORTSMOUTH HARBOR GDM

Appendix D
Economic Analysis

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PORTSMOUTH HARBOR GDM
APPENDIX D
ECONOMIC ANALYSIS

Methodology

The economic justification of the proposed improvement was determined by comparing benefits accruing to the project over its economic lifespan to project costs. The comparison is made possible by placing benefits and costs on an annual basis using the interest and amortization rate of 8 5/8 percent currently applicable to Federal projects. The economic life of the project is considered to be 50 years. A project is economically justified if the ratio of benefits to costs equals or exceeds one.

Costs

The NED Plan first cost, interest during construction, total investment cost and annual cost are shown in Table 1.

Table 1

Project Costs

NED Plan (Improvements to Area 1 and Area 3) First Cost	$17,920,000
Interest During Construction	1,021,000
Investment Cost	$18,941,000
Annual Charges*	$ 1,661,000

Benefits

Project improvements would result in benefits derived from: (1) projected savings in the cost of transporting commodities on the improved waterway, (2) reduction of risk to shipping, (3) operational savings, and (4) the intangible value provided for national defense and emergencies. Monetary values are assigned to the transportation cost savings, the reduction of risk resulting from the channel modifications, and the operational savings.

In determining project benefits discussions were held with representatives of the Piscataqua River Safety and Water Improvement Committee, the Portsmouth Pilots, and various terminal operators and shipping interests. These discussions led to the following findings:

1. All harbor users would benefit from improved safety.

* Interest and Amortization 8 5/8%, 50 year project life

2. Some users indicated the project would allow greater use of large ships and that they would definitely use the larger vessels to obtain efficiencies of scale and reduced transportation costs. Confidential letters from and records of interviews with all major companies involved in Waterborne Commerce at Portsmouth Harbor concerning their anticipated operations with and without the proposed plan of improvement are on file at New England Division Headquarters. The records show that some shippers will operate the same size ships whether or not the proposed project is implemented, whereas other shippers will use more of the larger 40,000 DWT vessels instead of smaller 30,000 and 20,000 DWT vessels.

The shippers explained that if one of the newer more highly maneuverable 40,000 DWT ships, having more powerful engines and better rudder and screw configurations is available when their need arises they will risk bringing in the larger vessel, but if one is not available they schedule a smaller ship. Other shippers simply stated they would be more inclined to schedule the larger ships if the level of risk is reduced. Confidence in the level of safety will induce them to bring in additional larger vessels.

3. Petroleum products would comprise the largest group of commodities that could be transported at a reduced cost if the project is implemented.

4. There would be a reduction in the transportation costs of salt shipments if the project is completed.

5. Some users would gain incidental operational savings achieved when vessels are turned.

6. Gypsum, lumber, metals, machinery, and small quantities of other commodities are shipped through Portsmouth. It was determined that these shipping interests would maintain use of their present vessels or vessels of the same dimensions and would, therefore, not obtain transportation savings.

7. Areas 1 and 3 together are the key for transportation savings and risk reduction. A substantial increase in the use of large vessels will occur only with channel modifications in both areas. Improvements to one area alone would effectively worsen the safety hazard.

Assigning a dollar value to the benefit resulting from the removal of hazards to shipping and thus reducing risk would normally require the development of a probability schedule of potential damages. Risk would be viewed as the probability of damages multiplied by the dollar amount of damages. Since few navigation-related accidents and damages have actually occurred in the past as a result of a state law requiring pilots on all ships, it is not possible to develop the damage-frequency information required for analysis in this manner. An approximation of the benefit of risk reduction, however, is developed using unit transportation costs.

The value provided to national defense and emergencies is related to the fact that the daily movement of commodities on U.S. waterways is vital for security. Since this benefit is considered intangible, it is not quantifiable but becomes especially significant when one considers that Pease Air Force Base and the Portsmouth U.S. Naval Shipyard are located in the vicinity of the project area.

Types and Volumes of Commodity Flows

The chief commodities that move on the existing waterway are petroleum products. These products comprise approximately 80 percent of the marine commerce shipped through the harbor. Significant quantities of limestone (gypsum) and salt are also received. The chief shipments out of Portsmouth are petroleum products and iron and steel scrap. Table 2 provides a historical summary of commerce at Portsmouth Harbor. The table shows that total tonnage has increased in a relatively steady manner throughout the past decade. A detailed picture of the freight traffic for the latest availabe year, 1982 is presented in Table 3.

Commodity trends for the most significant products shipped through Portsmouth are displayed in Table 4. Limestone (gypsum) is imported from Canada. Salt comes from Mexico. Petroleum products are received chiefly from Venezuela, the U.S. gulf area, Boston, New York-New Jersey, and Pennsylvania. Ports of origin and destination for petroleum products shipped through Portsmouth are illustrated in Figure D-1.

Table 2

Historical Summary of Commerce at Portsmouth Harbor
(Short Tons)

		Foreign		Domestic coastwise			
Year	Total	Imports	Exports	Receipts	Shipments	Local	Internal
1982	2,267,083	1,181,731	157,657	906,268	13,865	5,735	1,827
1981	3,072,214	1,707,674	182,959	880,250	251,165	50,110	56
1980	2,783,781	1,169,332	182,024	1,258,425	141,367	32,633	-
1979	3,519,926	1,718,795	127,338	1,373,633	278,369	21,791	-
1978	3,305,303	1,879,913	84,932	1,053,817	274,614	12,027	-
1977	3,499,854	1,977,235		1,021,729	469,647	31,243	-
1976	3,143,313	1,471,028	32,763	1,146,580	433,938	59,000	4
1975	2,943,343	1,370,991	13,297	1,049,254	445,235	64,566	
1974	2,364,290	1,056,345	7	1,004,608	249,720	53,609	1
1973	2,314,900	1,294,195	13,453	944,262	62,984	-	6
1972	2,188,071	1,178,455		976,998	32,605	-	13
1971	2,174,425	1,271,111	10	856,980	46,321	-	3
1970	2,187,303	1,092,276	1,957	1,036,435	53,585	3,042	8
1969	1,795,915	953,842	-	835,874	6,197	-	2

Source: Waterborne Commerce of the United States

Table 3

Portsmouth Harbor 1982 Freight Traffic

(Short Tons)

PORTSMOUTH HARBOR, N. H.

SECTION INCLUDED: FROM MOUTH TO NEWINGTON, N. H., ON THE WEST BANK OF THE PISCATAQUA RIVER. CONTROLLING DEPTH: 33.0 FEET IN THE 35-FOOT CHANNEL TO SIMPLEX DOCK; THENCE 30 FEET TO UPSTREAM LIMIT. PROJECT DEPTH: 35 FEET AT MEAN LOW WATER OVER LEDGES.

COMPARATIVE STATEMENT OF TRAFFIC

YEAR	TONS	PASSENGERS	YEAR	TONS	PASSENGERS
1973	2,314,900	----------	1978	3,305,303	102,586
1974	2,366,290	----------	1979	3,519,926	109,566
1975	2,943,343	----------	1980	2,783,781	51,160
1976	3,143,313	77,584	1981	3,072,214	191,800
1977	3,499,854	96,284	1982	2,267,083	----------

FREIGHT TRAFFIC, 1982

(SHORT TONS)

COMMODITY	TOTAL	FOREIGN		DOMESTIC			
				COASTWISE		INTERNAL	LOCAL
		IMPORTS	EXPORTS	RECEIPTS	SHIPMENTS	RECEIPTS	
TOTAL	2,267,083	1,181,731	157,657	906,268	13,865	1,827	5,735
0121 TOBACCO, LEAF	1,775	1,775	----------	----------	----------	----------	----------
0131 FRESH FRUITS	573	----------	573	----------	----------	----------	----------
0911 FRESH FISH, EXCEPT SHELLFISH	1,829	2	----------	----------	----------	1,827	----------
1091 NONFERROUS ORES, CONCENT, NEC	11,024	11,024	----------	----------	----------	----------	----------
1411 LIMESTONE	139,866	139,868	----------	----------	----------	----------	----------
1412 BUILDING STONE, UNWORKED	65	----------	65	----------	----------	----------	----------
1491 SALT	287,823	287,823	----------	----------	----------	----------	----------
2031 FISH AND SHELLFISH, PREPARED	51	51	----------	----------	----------	----------	----------
2039 PREP FRUIT AND VEG JUICE, NEC	210	----------	210	----------	----------	----------	----------
2081 ALCOHOLIC BEVERAGES	5,550	5,550	----------	----------	----------	----------	----------
2099 MISCELLANEOUS FOOD PRODUCTS	21	----------	21	----------	----------	----------	----------
2211 BASIC TEXTILE PRODUCTS	12	10	2	----------	----------	----------	----------
2421 LUMBER	1,114	1,036	78	----------	----------	----------	----------
2491 WOOD MANUFACTURES, NEC	16	1	15	----------	----------	----------	----------
2511 FURNITURE AND FIXTURES	5	2	3	----------	----------	----------	----------
2631 PAPER AND PAPERBOARD	683	----------	683	----------	----------	----------	----------
2691 PULP AND PAPER PRODUCTS, NEC	4	4	----------	----------	----------	----------	----------
2711 PRINTED MATTER	1	1	----------	----------	----------	----------	----------
2819 BASIC CHEMICALS AND PROD, NEC	36	36	----------	----------	----------	----------	----------
2821 PLASTIC MATERIALS	44	----------	44	----------	----------	----------	----------
2823 SYNTHETIC (MAN-MADE) FIBERS	6	----------	6	----------	----------	----------	----------
2841 SOAP	11	----------	11	----------	----------	----------	----------
2851 PAINTS	91	91	----------	----------	----------	----------	----------
2891 MISCELLANEOUS CHEMICAL PROD	6	6	----------	----------	----------	----------	----------
2911 GASOLINE	* 214,160	----------	----------	214,160	----------	----------	----------
2912 JET FUEL	80,769	----------	----------	74,350	6,419	----------	----------
2913 KEROSENE	28,018	----------	----------	28,018	----------	----------	----------
2914 DISTILLATE FUEL OIL	* 540,578	98,978	----------	428,419	7,446	----------	5,735
2915 RESIDUAL FUEL OIL	* 683,983	566,378	----------	117,605	----------	----------	----------
2918 ASPHALT, TAR, AND PITCHES	77,163	33,488	----------	43,675	----------	----------	----------
2921 LIQUEFIED GASES	* 28,819	28,819	----------	----------	----------	----------	----------
3011 RUBBER AND MISC PLASTIC PROD	26	16	10	----------	----------	----------	----------
3111 LEATHER AND LEATHER PRODUCTS	733	400	333	----------	----------	----------	----------
3211 GLASS AND GLASS PRODUCTS	1,435	1,435	----------	----------	----------	----------	----------
3315 IRON, STEEL SHAPES, EXC SHEET	22	22	----------	----------	----------	----------	----------
3316 IRON AND STEEL PLATES, SHEETS	838	838	----------	----------	----------	----------	----------
3317 IRON AND STEEL PIPE AND TUBE	2	2	----------	----------	----------	----------	----------
3318 FERROALLOYS	1,988	1,988	----------	----------	----------	----------	----------
3319 IRON AND STEEL PRODUCTS, NEC	611	611	----------	----------	----------	----------	----------
3321 NONFERROUS METALS, NEC	3,763	----------	3,763	----------	----------	----------	----------
3322 COPPER ALLOYS, UNWORKED	144	144	----------	----------	----------	----------	----------
3324 ALUMINUM AND ALLOYS, UNWORKED	39	39	----------	----------	----------	----------	----------
3411 FABRICATED METAL PRODUCTS	910	868	42	----------	----------	----------	----------
3511 MACHINERY, EXCEPT ELECTRICAL	147	68	38	41	----------	----------	----------
3611 ELECTRICAL MACH AND EQUIP	356	275	81	----------	----------	----------	----------
3711 MOTOR VEHICLES, PARTS, EQUIP	42	42	----------	----------	----------	----------	----------
3911 MISC MANUFACTURED PRODUCTS	40	40	----------	----------	----------	----------	----------
4011 IRON AND STEEL SCRAP	151,427	----------	151,427	----------	----------	----------	----------
4012 NONFERROUS METAL SCRAP	252	----------	252	----------	----------	----------	----------
4112 COMMODITIES, NEC	6	6	----------	----------	----------	----------	----------

TOTAL TON-MILES. 8,450,310.

Table 4

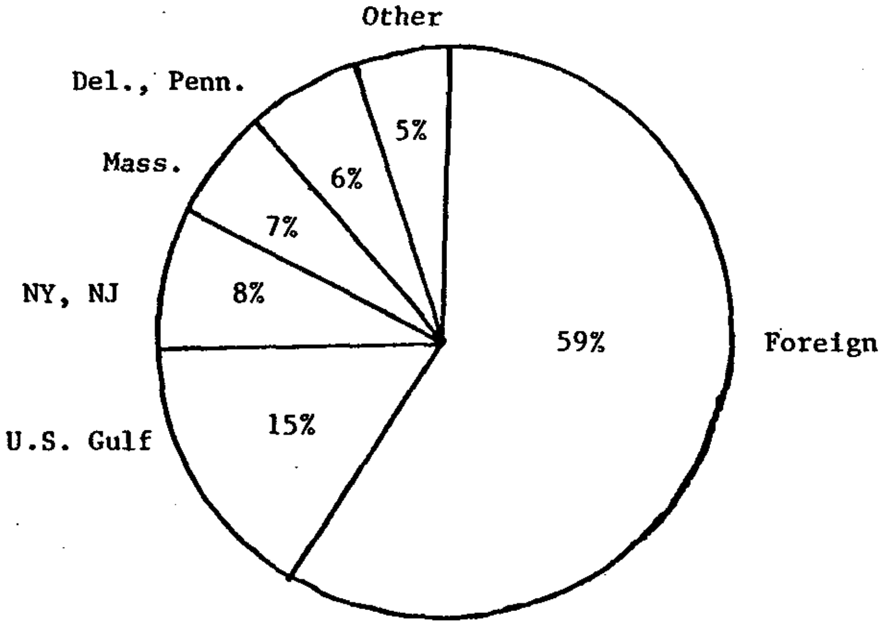
Commodity Trends at Portsmouth Harbor

Year	Petroleum Products (Imports, coastwise receipts)	Limestone (imports)	Salt (imports)
	Commodities in Short Tons		
1969	1,467,281	90,832	209,472
1970	1,811,918	133,663	146,656
1971	1,859,572	96,703	159,023
1972	1,830,045	133,569	170,194
1973	2,031,871	115,706	84,277
1974	1,807,177	149,023	31,534
1975	2,231,732	135,669	52,069
1976	2,368,649	164,079	183,251
1977	2,931,504	85,627	144,799
1978	2,578,349	157,739	197,642
1979	2,707,554	157,818	214,035
1980	2,161,789	109,219	198,919
1981	2,200,779	195,376	180,079
1982	1,633,890	139,868	287,823

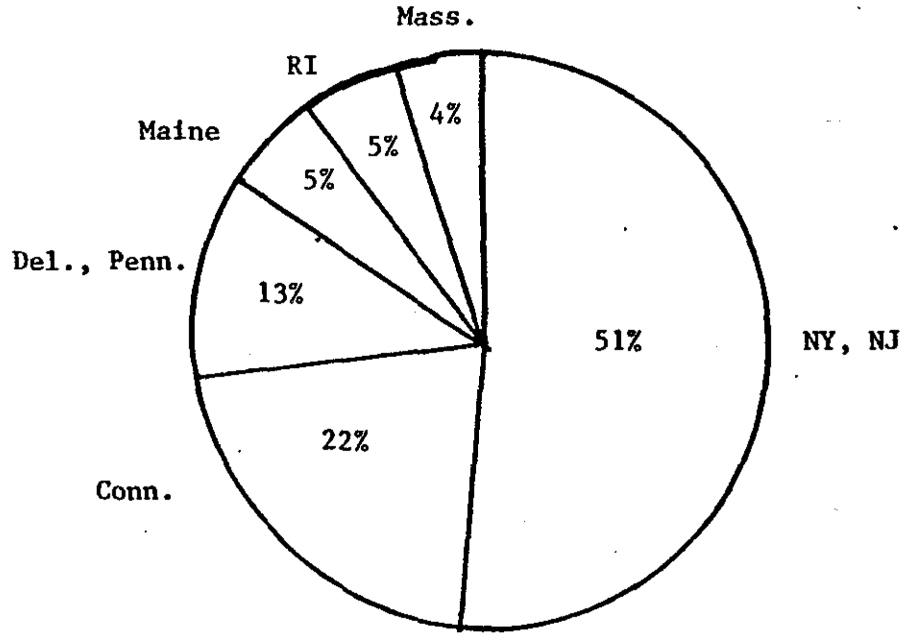
Source: Waterborne Commerce of the United States

FIGURE D-1. ORIGINS AND DESTINATIONS OF PETROLEUM PRODUCTS (1978)

Petroleum Products Arriving at Portsmouth by Origin



Petroleum Products Leaving Portsmouth by Destination



SOURCE: Date Extracted from <u>Waterborne Commerce</u> statistics, 1978.

Waterborne Commerce Projections

In order to formulate plans for port maintenance and improvement, the New England Division of the U.S. Army Corps of Engineers retained Resource Planning Associates Inc. (RPA) to project shipments of petroleum products through the 17 major ports in New England including Portsmouth Harbor.* To carry out the study various forecasts of demand for petroleum products for the New England region as a whole were surveyed. The projections of the U.S. Department of Energy, Energy Information Administration (EIA) were selected as the most comprehensive and accurate estimates of the region's future use of six principal petroleum products: residual, distillate, gasoline, jet fuel, liquid gas, and naptha. Using these projections and data developed on product consumption among the states in 1977, RPA estimated the amounts of each fuel that will be shipped through each major port in 1985, 1990, and 1995.

RPA concluded that shipments of petroleum products through New England ports will decrease in the long run. After an increase in the short term, total volume will begin to decline. The most rapid declines in petroleum product consumption are anticipated to occur in the electric utilities and industrial sector, where residual and distillate fuels will be increasingly replaced by coal. Consumption in the residential, commercial, and transportation sectors is expected to remain relatively constant over time.

The specific projections for the port of Portsmouth are presented in Table 5. RPA's projections end in 1995 due to the extremely unpredictable nature of the petroleum industry. Projected commerce was therefore held constant for the years following 1995. The projections for products not covered by RPA were based on an analysis of commodity trends and discussion with the commodity shipper/receivers.

*Resource Planning Associates, Projections of Petroleum Product Shipments through New England Ports, 1979 - on file at New England Division Headquarters

Table 5

Commodity Projections - Portsmouth Harbor

(Thousands of Short Tons)

Commodity	Actual					Projected		
	1978	1979	1980	1981	1982	1985	1990	1995
Salt	197.6	214.0	198.9	180.1	287.8	260.4	260.4	260.4
Crude Petroleum	383.0	373.5	269.6	198.3	-	650.0	690.0	730.0
Liquid Gas	109.7	78.2	79.9	75.3	28.8	202.0	196.0	193.0
Petroleum Products[1]	2097.3	2255.9	1812.2	1927.1	1605.5	2307.7	2337.7	2174.0

Source: Resource Planning Associstes, terminal operators, various industry sources.

[1]Excludes liquified gases, includes kerosene, other

Vessel Fleet Composition

Most of the commodity tonnage shipped to Portsmouth arrives on vessels in the 30-35,000 DWT range. An indicator of sizes of the vessels using the harbor is provided by Table 6 which shows trips and drafts from 1969 to 1982. The table also reveals that the total number of vessels calling on Portsmouth has risen substantially during this time period.

As previously noted, vessels carrying petroleum products account for approximately 80 percent of all harbor tonnage. Information extracted from Waterborne Commerce data indicates that between 15 snd 20 percent of petroleum tonnage is delivered by barge, while the remainder arrives on tankers.

Table 6

Trips and Drafts of Vessels

(Inbound Only)

Draft (ft)	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
37				8	11	–	6	7	4	4	2	6	5
36				16	18	32	13	10	9	9	15	14	9
35	24	36	42	18	15	16	17	17	13	9	23	10	17
34	9	12	17	15	11	11	14	10	10	15	8	9	9
33	2	6	11	14	9	7	8	7	2	7	1	4	2
32	6	5	4	3	4	7	8	9	12	19	5	4	10
31	6	4	3	9	7	14	8	11	14	14	14	16	11
30	3	3	2	4	6	5	6	3	1	3	5	5	6
29	4	5	–	–	1	–	1	3	5	3	5	5	6
28	4	4	3	7	–	5	2	5	5	2	3	1	2
27	2	2	1	2	2	2	2	5	3	2	1	2	5
26	8	11	2	6	4	9	8	5	3	3	5	2	6
25	5	10	7	3	3	2	5	5	4	6	7	6	5
24	8	5	6	5	7	–	3	2	4	4	6	5	9
23	2	6	2	5	3	5	3	4	1	5	6	8	3
22	3	3	2	7	5	2	3	7	3	7	8	6	5
21	5	7	8	9	6	2	2	3	2	3	8	13	6
20	4	–	6	8	5	1	2	3	4	2	8	3	6
19	10	7	4	4	2	5	3	4	1	5	2	2	4
18 and less	1501	585	428	585	393	354	422	300	301	244	237	211	206
Total	1606	711	548	728	512	478	536	419	401	366	366	334	329

Source: Waterborne Commerce of the United States

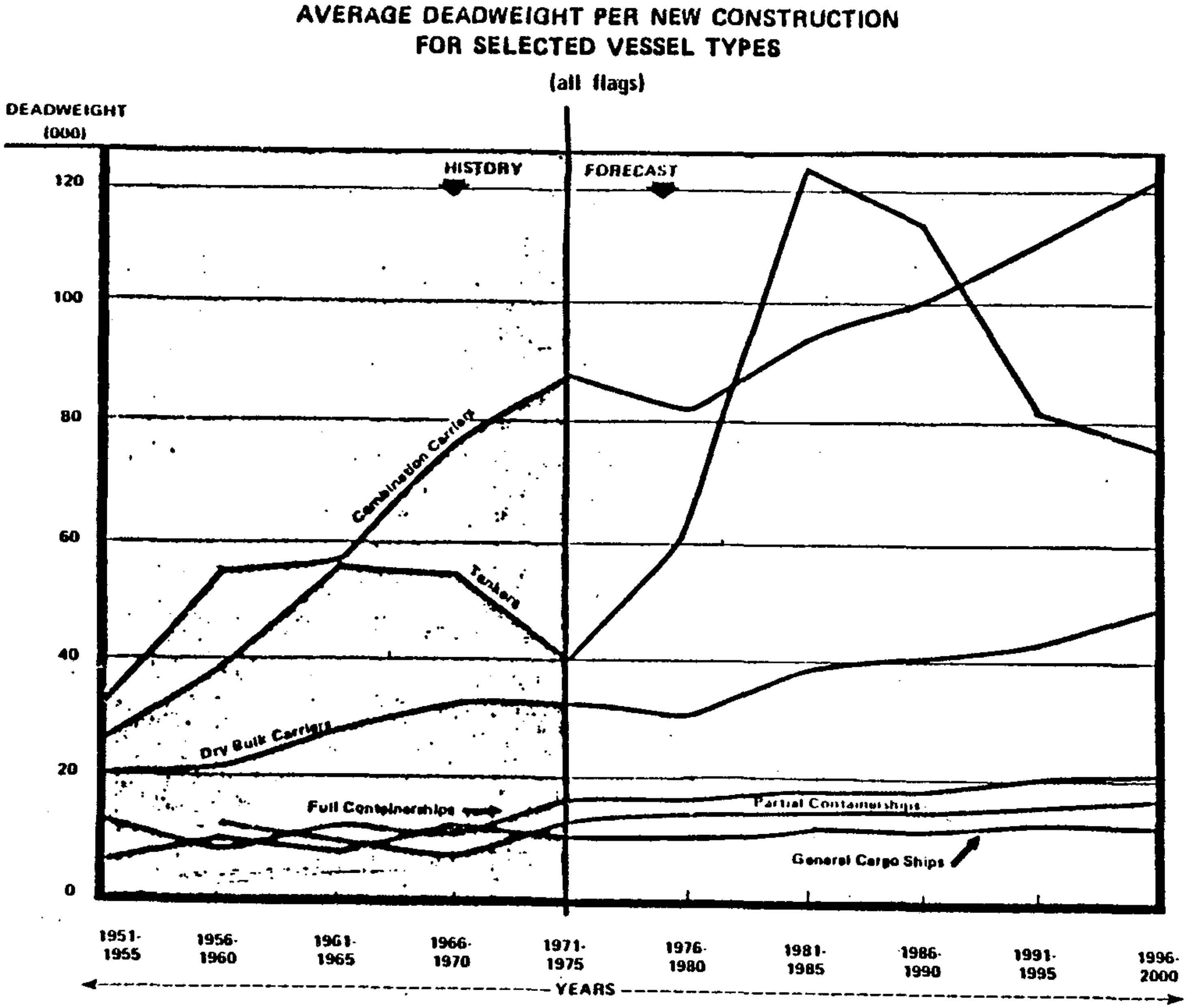
Note: Drafts shown are "out of trim" values and not draft amidships.
They are rounded up to next even foot.

Domestic and World Fleet Trends

According to a merchant fleet forecast prepared for the U.S. Maritime Administration, the average deadweight of new construction for the world fleet will continue to increase consistent with historical growth (see Figure D-2). One exception is tankers where replacement requirements for large numbers of small vessels will cause the average size of tanker construction to drop significantly after 1985.

Although relatively small tankers will be built, according to Portsmouth shipping interests, the smallest sizes in use at Portsmouth are becoming scarce. A cursory review of various shipping publications reveals that the smallest U.S. flag tankers ordered for the near-term future are ships similar to two 34,400 DWT tankers recently delivered by Sun Ship, Inc. for use on various U.S. intercoastal trade routes. American Tankship has applied for financial assistance for the construction of three 37,500 DWT tankers for use at Eastern Coast ports. Also, Exxon plans to take delivery on three 43,000 ton tankers during 1983 and 1984. The cursory review of shipping publications did not reveal any anticipated U.S. constructions below 30,000 DWT.

Temple, Barker and Sloane, Inc. forecasts of new constructions indicate that foreign tankers below 30,000 DWT will be built for use in U.S.-foreign trade. Also a small number of U.S. flag tankers below 30,000 DWT will be built for use in U.S.-foreign trade. These construction forecasts are presented in Table 7.



AVERAGE DEADWEIGHT PER NEW CONSTRUCTION
FOR SELECTED VESSEL TYPES
(all flags)
DEADWEIGHT
(000)
120
100
80
60
40
20
0
HISTORY
FORECAST
Combination Carriers
Tankers
Dry Bulk Carriers
Full Containerships
Partial Containerships
General Cargo Ships
1951-
1955
1956-
1960
1961-
1965
1966-
1970
1971-
1975
1976-
1980
1981-
1985
1986-
1990
1991-
1995
1996-
2000
YEARS

Figure D-2

Table 7

New Constructions
Liquid Bulk Carriers

Deadweight (000)	1981-1985 Number of Ships World	US	1986-1990 Number of Ships World	US	1991-1995 Number of Ships World	US	1996-2000 Number of Ships World	US
1-10	3	0	2	0	2	0	11	0
10-20	5	0	3	0	5	0	9	0
20-30	16	3	13	1	18	0	51	0
30-50	23	12	17	7	24	3	70	4
50-70	11	1	6	2	10	1	38	0
70-125	11	1	5	1	8	2	39	1
125-175	14	0	10	0	13	1	15	1
175-225	8	0	5	0	3	0	10	0
225-300	15	0	9	0	5	0	13	3
300+	10	3	6	2	3	3	9	4

Source: Merchant Fleet Forecsst of Vessels in U.S. Foreign Trade, Temple, Barker and Sloane, Inc., Wellesley Hills, MA prepared for the Maritime Administration, Washington, DC, May 1978.

Although small tankers will comprise a limited portion of future world fleet construction, the rate of replacement for these vessels will fall below the rate of scrapping. The result will be a decrease in the absolute number of tankers below 30,000 DWT in future years.

Although small tankers may be in short supply, large barges have been replacing small tankers in recent years. The role of tugs and barges has expanded from short-haul harbor service to encompass long-haul coastwise, intercoastal, and worldwide traffic. Barges of up to 55,000 DWT are under construction.

In general each generation of tugs and barges is successively more expensive. First generation tugs and barges were typically small and used for short-haul distances. Second generation tugs and barges are usually designed for coastwise service and the tugs tend to be heavier, more powerful and more extensively outfitted. The cost of third generation integrated tug-barge systems can approach or exceed the cost of self-propelled vessels with equivalent capacity. As barges become more expensive and hauling distances for barges increase, the costs of small tankers versus barges tend to equalize.

Future Fleet at Portsmouth Under With and Without Project Conditions

The largest fully loaded tankers in use at Portsmouth are approximately 40,000 DWT. Because the berths at the various facilities in the harbor average 35 to 38 feet in depth, and the channel itself is at 35 feet, a ship with drafts varying from 35 to 37 feet must be brought in utilizing the tides. Thus, even with the recommended improvements, the largest fully loaded ship that could be brought in is a 40,000 DWT vessel. This same size is now brought in, but under hazardous conditions. Larger vessels, ranging up to 60,000 DWT's are also brought in, but in a lightloaded condition. Because of the vertical height restriction of 135 feet determined by the bridges, only certain of these vessels can come in.

A fully loaded 45,000 DWT vessel, for example, would have a draft of up to 40 feet and could be utilized today only if it were lightloaded. One individual facility has deepened its berth to 38 feet plus 2 feet of overdepth to handle ships this size. A fully loaded 45,000 DWT tanker with up to a 40 foot draft would have difficulty even with the eight foot tide and the channel depth of 35 feet. Such a ship would have to be lightloaded and even then a question of safety is raised because of length and beam.

Today, bringing in a 40,000 DWT vessel presents a safety hazard because of its length and width ranging up to 700 feet and 100 feet respectively. Few of these vessels are utilized because of the safety risks at the bends and between the bridges. Smaller vessels of 16 to 21,000 DWT's and up to 430 feet long are considered by the pilot to be relatively risk free in transiting the harbor. Although world and U.S. shipping trends show a movement toward larger vessels (wider and longer without having deeper drafts), expanded use of large ships at Portsmouth will not be practical without channel improvements to reduce risk.

Without structural modifications to the harbor, the average vessel size at Portsmouth can be expected to exhibit only a slight increase as smaller vessels are retired. To some extent, increased use of large barges can be expected to partially compensate for the forecasted decline in the number of small tankers. However, as small vessels are retired, it is likely that slightly greater use of large tankers will contribute to a worsening of the safety hazard at the harbor.

If a structural plan is implemented, it will become feasible to make use of more tankers in the 35-45,000 DWT range. Based on discussions with terminal operators and the pilots, the perception is that the harbor will be safer under the with project condition. Although many of the ships at Portsmouth are currently in the 35-40,000 DWT category, they tend to be concentrated at the lower end of the range. Because of a wide varience in maneuverability of ships in this range, many cannot be brought in safely now and have been refused entry into the harbor by the chief pilot. If the channel is improved, Portsmouth shipping interests indicate that they will use more large vessels and a shift toward the upper limit of the 35-45,000 DWT range can be expected. The project would encourage use of more 40-45,000 DWT vessels by making it safer for them to transit the channel.

Among the ships that call on Portsmouth are liquified petroleum gas (LPG) carriers. Like conventional tankers, they carry liquid petroleum in bulk. However, the characteristics of the LPG vessels are much different than traditional tankers. The gas ships are designed to carry cargo pressurized, semi-refrigerated, fully refrigerated, etc. Also, in place of DWT, which describes the carrying capacity of a tanker by weight, cubic meters are used to describe the carrying capacity of the LPG vessels in terms of volume.

At Portsmouth, propane and butane are imported on LPG vessels. Much of the cargo is received on 40,000 cubic meter ships. Most LPG carriers being built today, however, are in the 50-59,000 cubic meters range. If the project is implemented, there would be greater opportunity for safe delivery using the 50-59,000 cubic meter ships.

Salt is imported to Portsmouth with dry bulk vessels of up to 50,000 DWT. These ships first discharge part of their cargo at another port before entering Portsmouth. According to the salt importer, the harbor modifications would enable fully-loaded 45-50,000 DWT ships to be utilized by allowing for improved maneuverability.

A complete vessel fleet forecast for Portsmouth Harbor is presented in Table 8. This forecast is based on an analysis of U.S. and world fleet trends and on discussions with Portsmouth terminal operators and shipping interests. The projections of future vessels considers both the "with project condition" and "without project condition". Additionally, both foreign and domestic fleet forecasts are provided. Projected vessel trips for each size ship for various years over the project life are shown in Table 9.

Table 8

Portsmouth Harbor Fleet Projections

Projected Size Distribution of Tanker Fleet

Transporting Petroleum Products to Portsmouth by Percentage

Without Project

Foreign

% of Tonnage

DWT	Midpoint	1981	1985	1995	2005	2015	2025	2035
0-15,000	7,500	0	0	0	0	0	0	0
15-25,000	20,000	16	16	16	15	15	14	14
25-35,000	30,000	37	37	37	35	35	34	34
35-45,000	40,000	47	47	47	50	50	52	52

US

% of Tonnage

DWT	Midpoint	1981	1985	1995	2005	2015	2025	2035
0-15,000	7,500	41	41	41	41	41	41	41
15-25,000	20,000	19	19	19	19	19	18	18
25-35,000	30,000	36	36	36	35	35	34	34
35-45,000	40,000	4	4	4	5	5	7	7

With Project

Foreign

% of Tonnage

DWT	Midpoint	1981	1985	1995	2005	2015	2025	2035
0-15,000	7,500	0	0	0	0	0	0	0
15-25,000	20,000	16	8	8	7	7	5	5
25-35,000	30,000	37	20	20	18	18	15	15
35-45,000	40,000	47	72	72	75	75	80	80

US

% of Tonnage

DWT	Midpoint	1981	1985	1995	2005	2015	2025	2035
0-15,000	7,500	41	41	41	41	41	41	41
15-25,000	20,000	19	11	11	10	10	8	8
25-35,000	30,000	36	24	24	22	22	21	21
35-45,000	40	4	24	24	27	27	30	30

Projected Size Distribution of LPG Fleet Transporting

Propane, Butane to Portsmouth by Percentage (foreign flag)

Without Project

% of Tonnage

Cubic Meters 1981	1981	1985	1995	2005	2015	2025	2035
10-29,000	24	10	10	10	10	10	5
30,39,000	33	20	20	10	10	10	10
40-49,000	22	20	20	20	20	20	25
50-59,000	21	50	50	60	60	60	60

With Project

Cubic Meters 1981	1981	1985	1995	2005	2015	2025	2035
10-29,000	24	0	0	0	0	0	0
30-39,000	33	15	15	15	15	15	15
40-49,000	22	15	15	15	15	15	15
50-59,000	21	70	70	70	70	70	70

Projected Size Distribution of Dry Bulk Fleet Transporting

Salt to Portsmouth

Without Project

% of Tonnage

DWT	1981	1985	1995	2005	2015	2025	2035
25,000 Av	20	20	20	20	20	20	20
50,000 Av	80	80	80	80	80	80	80

With Project

% of Tonnage

DWT	1981	1985	1995	2005	2015	2025	2035
25,000 Av	20	20	20	20	20	20	20
50,000 Av	80	80	80	80	80	80	80
(1 port)							

Table 9

Projected Vessel Trips for Deep Draft Traffic ***

Without Project

Vessel Type	1981	1985	1995	2005	2015	2025	2035
TANKER, BARGE							
(petroleum)*							
7,500 DWT	63	72	71	71	71	71	71
20,000 DWT	24	27	26	26	26	25	25
30,000 DWT	35	39	38	37	37	35	35
40,000 DWT	20	23	23	24	24	26	26

With Project

Vessel Type	1981	1985	1995	2005	2015	2025	2035
7,500 DWT	63	72	71	71	71	71	71
20,000 DWT	24	14	14	12	13	10	10
30,000 DWT	35	24	23	21	21	18	18
40,000 DWT	20	41	40	43	43	47	47

Without Project

Dry Bulk (Salt)							
20,000 DWT	2	2	2	2	2	2	2
50,000 DWT**	7	7	7	7	7	7	7

With Project

25,000 DWT	2	2	2	2	2	2	2
50,000 DWT	7	4	4	4	4	4	4

*Includes Crude, LPG

**Two ports

***Coastwise shipments, imports only. Table is intended to provide indication of rate of change of vessel trips. Absolute numbers are only approximations. These are fully loaded ships required to carry only the commerce destined for Portsmouth. Some ships offload a partial shipload at Portsmouth, then proceed to other ports, as shown by the larger number of actual trips in Table 6. Benefits are claimed only for commerce and trips necessary for fully loaded ships to serve Portsmouth.

Transportation Cost Savings

Table 10 displays 1984 hourly operating costs for various vessel types. These general costs were used to determine the transportation cost per ton for commodities shipped to Portsmouth. Unit costs were based on round trip distances from chief ports of origin and include an allowance for tidal delay. Because all vessels must dock during slack water at Portsmouth tidal delay was held constant for all vessel sizes. A typical computation of vessel voyage is shown in Table 11. Average unit costs for various size vessels are presented in Table 12.

By allowing more large petroleum ships to use the port, structural channel modifications would result in transportation cost savings. These savings are based on a comparison of transportation costs without the project and transportation costs with the project. Annual costs and savings are displayed in Table 13. A summary of benefits is provided in Table 14.

Transportation cost savings are computed for petroleum vessels transiting the main channel and emergency maneuvering area in Area 1. Incidental transportation and operational savings are also computed for ships visiting the Port Authority facilities and the salt termilnal. Larger salt ships (45,000 to 50,000 DWT) can only be turned if light-loaded. The emergency maneuvering area will permit fully loaded salt ships to be turned safely, thus realizing cost/ton savings achieved by the use of the larger vessels aready calling at Portsmouth.

Table 10

Vessel Hourly Operating Costs (1984 Rates)

Type	Size	Foreign Flag At Sea	Foreign Flag In Port	U.S. Flag At Sea	U.S. Flag In Port
Tankers	20,000 DWT	$ 618	$ 396	$1,400	$1,090
	30,000 DWT	$ 741	$ 428	$1,593	$1,132
	40,000 DWT	$ 804	$ 462	$1,775	$1,287
	50,000 DWT	$ 880	$ 480	$1,905	$1,357
Dry Bulk	25,000	$ 642	$ 357		
	50,000	$ 849	$ 437		
LPG	10-29,000 cm	$11,108	$ 8,108		
	30-39,000 cm	$13,589	$ 9,467		
	40-49,000 cm	$16,936	$10,828		
	50-59,000 cm	$24,335	$11,386		

Barge - Cost Per Barrel*
- from Boston: $0.38
- from New York $1.14

* includes surcharge

Source: Department of the Army, Water Resources Support Center, Corps of Engineers, February 1985, Barge Companies

Table 11

Typical Calculation of Vessel Voyage Cost

U.S. Gulf - 30,000 DWT Vessel

a.	Round Trip Distance	4,200 naut. mi.
b.	Cruising time at 16 knots vessel speed	262 hrs.
c.	Cost at sea (262 hrs x 1,593/hr)	$417,366
d.	Cost in port (48 hrs x $1,132/hr)	$ 54,336
e.	Tidal delay costs (7.2 hrs x $1,132/hr)	$ 8,150
f.	Total Round Trip Cost	$479,852
g.	Tonnage: (DWT x 1.12) Net (x .96)	33,600 short tons 32,256
h.	Cost per ton ($608,184 - 32,256 tons)	$14.88

* This $14.88 cost is averaged with the costs from other ports of origin to obtain the $12.63 unit cost for a 30,000 DWT vessel in Table 12.

Table 12

Average Unit Transportation Costs

Commodity	Vessel Size	Flag	Unit Cost
Petroleum Products	7,500 DWT	U.S.	$ 4.94/ton
(excluding LPG)	20,000 DWT	U.S.	$17.39/ton
	20,000 DWT	Foreign	$ 8.40/ton
	30,000 DWT	U.S.	$12.63/ton
	30,000 DWT	Foreign	$ 6.59/ton
	40,000 DWT	U.S.	$10.64/ton
	40,000 DWT	Foreign	$ 5.38/ton
LPG	10-29,000 cm	Foreign	$ 8.68/cm
	30-39,000 cm	Foreign	$ 7.29/cm
	40-49,000 cm	Foreign	$ 6.57/cm
	50-59,000 cm	Foreign	$ 6.39/cm
Salt	25,000 DWT (avg.)	Foreign	$16.55/ton
	50,000 DWT (two ports)	Foreign	$12.07/ton
	50,000 DWT (one port)	Foreign	$11.84/ton

Table 13

Computation of Annual Transportation Costs and Savings for Petroleum Products*

Year 1985

DWT Group (000)	Without Project: Tonnage Percent	Without Project: Carried Volume (000)	Without Project: Unit Cost	Without Project: Total Cost (000)	With Project: Tonnage Percent	With Project: Carried Volume (000)	With Project: Unit Cost	With Project: Total Cost (000)	Savings $(000)
FOREIGN									
7.5	0	0	-	-	0	0	0	-	
20	16	279.2	8.40	2,345.3	8	139.6	8.40	1,172.6	
30	37	645.7	6.59	4,255.2	20	349.0	6.59	2,299.9	
40	47	820.2	5.38	4,412.7	72	1,256.4	5.38	6,759.4	
TOTAL		1,745.1		11,013.2		1,745.0		10,231.9	781.3
DOMESTIC									
7.5	41	497.2	4.97	2,456.2	41	497.2	4.94	2,456.2	
20	19	230.4	17.39	4,006.7	11	133.4	17.39	2,319.8	
30	36	436.6	12.63	5,514.3	24	291.0	12.63	3,675.3	
40	4	48.5	10.64	516.0	24	291.0	10.64	3,096.2	
TOTAL		1,212.7		12,493.2		1,212.6		11,547.5	945.7

*excludes LPG, includes crude

Table 13

Computation of Annual Transportation Costs and Savings for Petroleum Products*

Year 1995

DWT Group (000)	Without Project				With Project				Savings $(000)
	Tonnage Percent	Carried Volume (000)	Unit Cost	Total Cost (000)	Tonnage Percent	Carried Volume (000)	Unit Cost	Total Cost (000)	
FOREIGN									
7.5	0	0	-	-	0	0	0	-	
20	16	274.1	8.40	2,302.4	8	137.1	8.40	1,151.6	
30	37	633.9	6.59	4,177.4	20	342.7	6.59	2,258.4	
40	47	805.2	5.38	4,332.0	72	1,233.6	5.38	6,636.8	
TOTAL		1,713.2		10,811.8		1,713.4		10,046.8	765.0
DOMESTIC									
7.5	41	488.2	4.97	2,411.7	41	488.2	4.94	2,411.7	
20	19	226.2	17.39	3,933.6	11	131.0	17.39	2,278.1	
30	36	428.6	12.63	5,513.2	24	285.8	12.63	3,609.7	
40	4	47.6	10.64	506.5	24	285.8	10.64	3,040.9	
TOTAL		1,190.6		12,265.0		1,190.8		11,340.4	924.6

*excludes LPG, includes crude

Table 13

Computation of Annual Transportation Costs and Savings for Petroleum Products*

Year 2005, 2015

DWT Group (000)	Without Project: Tonnage Percent	Without Project: Carried Volume (000)	Without Project: Unit Cost	Without Project: Total Cost (000)	With Project: Tonnage Percent	With Project: Carried Volume (000)	With Project: Unit Cost	With Project: Total Cost (000)	Savings $(000)
FOREIGN									
7.5	0	0	-	-	0	0	0	-	
20	16	257.0	8.40	2,158.8	8	119.9	8.40	1,007.2	
30	37	599.7	6.59	3,952.0	20	308.4	6.59	2,032.4	
40	47	856.7	5.38	4,609.0	72	1,285.0	5.38	6,913.3	
TOTAL		1,713.4		10,719.8		1,713.3		9,952.9	766.9
DOMESTIC									
7.5	41	488.2	4.97	2,411.7	41	488.1	4.94	2,411.2	
20	19	226.2	17.39	3,933.6	11	119.1	17.39	2,071.8	
30	36	416.7	12.63	4,262.9	24	261.9	12.63	3,307.8	
40	4	59.5	10.64	633.1	24	321.5	10.64	3,420.8	
TOTAL		1,190.6		12,214.3		1,190.6		11,211.0	1,030.3

*excludes LPG, includes crude

Table 13

Computation of Annual Transportation Costs and Savings for Petroleum Products*

Year 2025, 2035

DWT Group (000)	Without Project Tonnage Percent	Without Project Carried Volume (000)	Without Project Unit Cost	Without Project Total Cost (000)	With Project Tonnage Percent	With Project Carried Volume (000)	With Project Unit Cost	With Project Total Cost (000)	Savings $(000)
FOREIGN									
7.5	0	0	-	-	0	0	0	-	
20	14	239.8	8.40	2,014.3	5	85.7	8.40	719.9	
30	34	582.5	6.59	3,838.7	15	257.0	6.59	1,693.6	
40	52	890.9	5.38	4,793.0	80	1,370.7	5.38	7,374.4	
TOTAL		1,713.2		10,646.0		1,713.4		9,787.9	858.1
DOMESTIC									
7.5	41	488.2	4.97	2,411.7	41	488.2	4.94	2,411.7	
20	18	214.3	17.39	3,726.7	8	95.3	17.39	1,657.3	
30	34	404.8	12.63	5,112.6	21	250.0	12.63	3,157.5	
40	7	83.3	10.64	886.3	30	357.2	10.64	3,800.6	
TOTAL		1,190.6		12,157.3		1,190.7		11,027.1	1,110.2

*excludes LPG, includes crude

Table 13

Computation of Annual Transportation Costs and Savings for LPG*

Cubic Meter Group (000)	Without Project: Tonnage Percent	Without Project: Carried Volume (000)	Without Project: Unit Cost	Without Project: Total Cost (000)	With Project: Tonnage Percent	With Project: Carried Volume (000)	With Project: Unit Cost	With Project: Total Cost (000)	Savings $(000)
Year: 1985									
10-29,000	10	34.3	8.58	297.7	0	0	-	-	
30-39,000	20	68.6	7.29	500.1	15	51.5	7.29	375.4	
40-49,000	20	68.6	6.57	450.7	15	51.5	6.57	338.4	
50-59,000	50	171.5	6.39	1,095.9	70	240.1	6.39	1,534.2	
TOTAL	100			2,344.4				2,248.0	96.4
Year: 1995									
10-29,000	10	32.8	8.68	284.7	0	0	-	-	
30-39,000	20	65.5	7.29	478.2	15	49.2	7.29	323.2	
40-49,000	20	65.6	6.57	431.0	15	49.2	6.57	323.2	
50-59,000	50	164.0	6.39	1,048.0	70	229.6	6.39	1,467.1	
TOTAL	100			2,241.9	100			2,149.0	92.9

*All foreign traffic

Table 13

Computation of Annual Transportation Costs and Savings for LPG*

Cubic Meter Group (000)	Without Project				With Project				Savings $(000)
	Tonnage Percent	Carried Volume (000)	Unit Cost	Total Cost (000)	Tonnage Percent	Carried Volume (000)	Unit Cost	Total Cost (000)	
Year: 2005, 2015									
10-29,000	10	32.8	8.68	284.7	0	0	-	-	
30-39,000	10	32.8	7.29	239.1	15	49.2	7.29	358.7	
40-49,000	20	65.6	6.57	431.0	15	49.2	6.57	323.2	
50-59,000	60	196.8	6.39	1,257.6	70	229.6	6.39	1,467.1	
TOTAL	100			1,212.4	100			2,149.0	63.4
Year: 2025, 2035									
10-29,000	5	16.4	18.68	142.4	0	0	-	-	
30-39,000	10	32.8	7.29	239.1	15	49.2	7.29	358.7	
40-49,000	25	82.0	6.57	538.7	15	49.2	6.57	323.2	
50-59,000	60	196.8	6.39	1,257.6	70	229.6	6.39	1,467.1	
TOTAL	100			2,177.8	100			2,149.0	28.8

*All foreign traffic

Table 13

Computation of Annual Transportation Costs and Savings for Salt*

Cubic Meter Group (000)	Without Project: Tonnage Percent	Without Project: Carried Volume (000)	Without Project: Unit Cost	Without Project: Total Cost (000)	With Project: Tonnage Percent	With Project: Carried Volume (000)	With Project: Unit Cost	With Project: Total Cost (000)	Savings $(000)
Year: 1985-2035									
25,000	20	52.1	16.55	862.3	20	52.1	16.55	862.3	
50,000	80	208.3	12.07	2,514.2	80	208.3	11.84	2,466.3	
TOTAL	100			3,376.5	100			3,328.6	47.9

Table 14

Summary of Transportation Cost Savings ($000)

Channel Modifications - Areas 1 and 3 - and Emergency Manuevering Area

Year	Petroleum Foreign	Petroleum Domestic	Total	LPG*	Total
1985	781	946	1,727	96	1,823
1995	765	925	1,690	93	1,783
2005	767	1,030	1,797	63	1,860
2015	767	1,030	1,797	63	1,860
2025	858	1,110	1,968	29	1,997
2035	858	1,110	1,968	29	1,997

*LPG shipments all foreign

Average Annual Equivalent - 1,830.9

Emergency Manuevering Area - Area 1

Year	Salt*	Average Annual Equivalent
1985-2035	47.9	47.9

*Salt shipments all foreign

OPERATIONAL SAVINGS

Incidental operational savings are expected to also accrue to the emergency maneuvering area proposed for Area 1. The existing channel here is 600 feet wide and in combination with berthing areas is now used to turn salt and scrap iron ships calling at the Granite State Minerals and New Hampshire Port Authority terminals respectively. Approximately 8 to 10 larger scrap iron vessels of the 28,000 to 32,000 DWT size and 625 and 645 feet in length are turned yearly in this area. In addition, about 6 to 8 salt vessels ranging from 40,000 to 50,000 DWT and up to 700 feet are also turned yearly (but only lightloaded).

With the proposed emergency maneuvering area in place, approximately 1000 feet will be made available for turning operations resulting in time savings and improved safety. Discussions with the chief harbor pilot indicate that roughly 1/2 hour could be saved each time a larger vessel is turned. With approximately 16 larger vessels coming in each year and tugboat time valued at $320/hour, the following savings would be realized:

16 vessels turned/year x 1/2 hour saved/turn x $320/hour
per tug X 3 tugs = $7,680 Say $7,700

The same time saving - 1/2 hour per turning operation will also mean less time in port for the 16 salt and scrap iron vessels. Using foreign in port hourly rates for 30,000 DWT scrap iron ships and 45,000 DWT salt vessels, the following saving are computed:

9 scrap iron vessels X $369/hour in port X 1/2 hour	= $1,661
7 salt vessels X $412/hour in port X 1/2 hours	= $1,442
TOTAL:	$3,103
SAY:	$3,100

Under existing conditions, these larger vessels are turned only at high tide. With the proposed emergency maneuvering area and channel width adding up to 1000 feet, turning operations, according to the chief pilot, could be conducted at any time during the 12.4 hour tide cycle, even at low water. Therefore, when a ship is finished unloading, waiting time for high tide would be eliminated. These savings are calculated as follows:

9 scrap iron vessels X $369/hour in port X 6 hours average waiting time	= $19,926
7 salt vessels X $412/hour in port X 6 hours average waiting time	= $17,304
TOTAL:	$37,230
SAY:	$37,200

Total incidental operational savings amount to the following:

Turning Savings-Tug	$7,700
-Vessel	3,100
Tidal Delay Savings	$37,200
TOTAL:	$48,000

Risk Analysis

Risk can be viewed as the probability of damages multiplied by the dollar amount of damages. Theoretically, the average annual amount of risk should equal the expected average annual losses resulting from navigation-related accidents. Damage-frequency information is required if risk is to be quantified in an exact manner. At Portsmouth this information is non-existent.

Despite the lack of information required for exact computation, an approximation of risk can be developed using the unit transportation costs displayed in Table 12. For example, the unit transportation cost for a 20,000 DWT vessel (U.S.) at Portsmouth is $17.39. For a 30,000 DWT vessel transportation cost is $12.63 per ton. A shipper apparently saves $4.76 per ton by using the larger vessel. But the apparent savings must be reduced by the increased risk of using the larger vessel. At this point we cannot state the exact amount of increased risk, but we do know that if it were more than $4.76, the shipper would not use the larger vessel because true costs per ton for the 30,000 DWT vessel would exceed those of a 20,000 DWT vessel. So we do know that the maximum dollar amount of risk created by moving from a 20,000 DWT vessel to a 30,000 DWT vessel is $4.76.

If given a choice, a shipper will not move to a larger vessel size if the additional risk of using that vessel exceeds the transportation savings. If a shipper is to maximize savings he will use larger and larger vessels until he reached the size at which the additional risk just equals the additional transportation savings. At Portsmouth, the largest vessels in use are in the 40,000 DWT range. Because of the dimensions of the river and harbor, use of larger vessels would bring about an unacceptable level of risk. If shippers at Portsmouth act in an economically rational manner, it can be assumed that the risk created by moving up from a 30,000 DWT vessel to a 40,000 DWT vessel just equals the additional transportation savings. According to Table 12 which lists unit transportation costs, this amount is $1.99. This is assumed to represent the total risk for a 40,000 DWT vessel.

For the with project condition it is necessary to determine to what degree risk is reduced by the proposed engineering improvements to the harbor. The most liberal standpoint would be to maintain that all risk - human and mechanical - would be eliminated and that shippers will then face no additional risk by moving up in vessel class size. On the other hand, it could be assumed that there would be no decrease in risk at all. Channel improvements do little to reduce risk of catastrophy due to human error or adverse conditions.

Both extremes seem unrealistic. Since the measurement of decreased risk is highly theorectical and can only be an approximation, a simplistic approach is taken. And since the risk being measured is the potential losses perceived by shippers, it is assumed that the source of this risk lies in Portsmouth Harbor itself. In essence, the decision of which ships to be utilized is based on harbor characteristics at Portsmouth. Discussions were held with the chief pilot at Portsmouth in an effort to estimate the allocation of risk in the harbor. Looking at the harbor overall, it is felt that 70 percent of the entire risk is located in Area 1, 20 percent in Area 3 and 10 percent in Area 2 which was considered in the Feasibility Report but was found to lack economic justification for its improvement. Within Area 1, 70 percent is allocated to the maneuvering area and the remaining 30 percent equally divided between the bend at Badger's Island and the Interstate Bridge passage. It is also assumed that the project will have its greatest effect on the larger vessels and will have a lesser effect on smaller vessels. More specifically it is assumed that there will be no effect on vessels below 20,000 DWT and that the maximum effect will be on the 30,000/40,000 DWT vessels. The above percentages are used to determine risk per ton as shown below for petroleum products.

Foreign - Petroleum Products

Vessel DWT Class	Total Harbor $ Risk/Ton	Areas 1 & 3 $ Risk/Ton	With Project $ Risk/Ton
20,000	0	0	
30,000	0.61	0.49	0.25
40,000	1.21	0.97	0.48

Information from Table 12 is used in combination with information in Table 13 in order to quantify the benefit of reduction in risk for U.S. and foreign traffic carrying petroleum products to terminals above the bridges and for foreign traffic to the terminals in Area 1. The annual benefits of reduction in risk are displayed in Table 15 and a summary in Table 16. It is assumed that the most that risk can be reduced for ships in the 30,000/40,000 DWT range by any engineering improvement in any area is 50 percent. Therefore, benefits from Table 15 are reduced by 50 percent when summarized in Table 16.

Risk benefits calculated for vessels docking at the terminals in Area 1 are derived solely from turning operations. Under existing conditions, the channel here is 600 feet wide. Larger salt and scrap iron ships varying from 625 to 700 feet in length are now turned in the channel and terminal berthing areas combined during high tide only. If Corps criteria were strictly adhered to, only a 400 foot length vessel would be turned in the 600 foot channel. This would represent a no risk situation compared to the high risk situation currently existing. Under the with project condition, however, a 1000 foot wide area (channel plus maneuvering area) would allow close to 700 foot vessels to be turned with no risk.

Although the quantification of reduction in risk is only an approximation, it seems to be a reasonable estimate. Given the high value of the vessels and cargo at Portsmouth and the extremely high potential clean-up cost for an accident, the prevention of even one bad mishap would be significantly beneficial. For example, a single 35,000 DWT tanker (U.S.) has a construction cost of over $630,000 on an average annual basis. This amount does not even include the prevention of the cost of clean-up and the cost of any law suit judgements. Although shippers generally have insurance to cover against the costs of an accident, project implementation would still prove beneficial by ultimately saving money for both shippers and insurance companies. Also, the potential prevention of the loss of human lives far outweights any potential monetary savings.

Table 15
Computation of Annual Risk Benefits for Petroleum Products*
Year 1985

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Risk/Ton	Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	Risk/Ton	Total Risk	Reduction in Risk (000)
FOREIGN									
7.5	0	0	0	-	0	0	0	-	
20	16	279.2	0	-	8	139.6	0	-	
30	37	645.7	.49	316.4	20	349.0	.25	87.3	
40	47	820.2	.97	795.6	72	1,256.4	.48	603.1	
TOTAL		1,745.1		1,112.0		1,745.0		690.4	421.6
DOMESTIC									
7.5	41	497.2	0	-	41	497.2	0	-	
20	19	230.4	0	-	11	133.4	0	-	
30	36	436.6	.78	340.5	24	291.0	.39	113.5	
40	4	48.5	1.59	77.1	24	291.0	.80	232.8	
TOTAL		1,212.7		417.6		1,212.6		346.3	71.3
								TOTAL:	492.9

*Excludes LPG, includes crude

Table 15
Computation of Annual Risk Benefits for Petroleum Products* Year 1995

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Without Project: Risk/Ton	Without Project: Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	With Project: Total Risk	Reduction in Risk (000)
FOREIGN									
7.5	0	0	0	-	0	0	0	-	
20	16	274.1	0	-	8	137.1	0	-	
30	37	633.9	.49	310.6	20	342.7	.25	85.7	
40	47	805.2	.97	781.0	72	1,233.6	.48	592.1	
TOTAL		1,713.2		1,091.6		1,713.4		677.8	413.8
DOMESTIC									
7.5	41	488.2	0	-	41	488.2	0	-	
20	19	226.2	0	-	11	131.0	0	-	
30	36	428.6	.78	334.3	24	285.8	.39	111.5	
40	4	47.6	1.59	75.7	24	285.8	.80	228.6	
TOTAL		1,190.6		410.0		1,190.8		340.1	69.9
								TOTAL:	483.7

*Excludes LPG, includes crude

Table 15
Computation of Annual Risk Benefits
for Petroleum Products*

Year 2005,2015

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Without Project: Risk/Ton	Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	Total Risk	Reduction in risk
				FOREIGN					
7.5	0	0	0	-	0	0	0	-	
20	15	257.0	0	-	7	119.0	0	-	
30	35	599.7	.49	293.9	18	308.4	.25	77.1	
40	50	856.7	.97	831.0	75	1,285.0	.48	616.8	
TOTAL		1,713.4		1,124.9		1,713.3		693.9	431.0
				DOMESTIC					
7.5	41	488.2	0	-	41	488.1	0	-	
20	19	226.2	0	-	10	119.1	0	-	
30	35	416.7	.78	325.0	22	261.9	.39	102.1	
40	5	59.5	1.59	94.6	27	321.5	.80	247.2	
TOTAL		1,190.6		419.6		1,190.6		359.3	60.3
								TOTAL:	491.3

*Excludes LPG, includes crude

Table 15
Computation of Annual Risk Benefits for Petroleum Products*

Year 2025, 2035

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Without Project: Risk/Ton	Without Project: Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	With Project: Total Risk	Reduction in Risk (000)
				FOREIGN					
7.5	0	0	0	-	0	0	0	-	
20	14	239.8	0	-	.5	85.7	0	-	
30	34	582.5	.49	285.4	15	257.0	.25	64.3	
40	52	890.9	.97	864.2	80	1,370.7	.48	657.9	
TOTAL		1,713.2		1,149.6		1,713.4		722.2	427.4
				DOMESTIC					
7.5	41	488.2	0	-	41	488.2	0	-	
20	18	214.3	0	-	8	95.3	0	-	
30	34	404.8	.78	315.7	21	250.0	.39	97.5	
40	7	83.3	1.59	132.4	30	357.2	.80	285.8	
TOTAL		1,190.6		448.1		1,190.7		383.3	64.8
								TOTAL:	492.2

*Excludes LPG, includes crude

Table 15
Computation of Annual Risk Benefits for LPG*

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Without Project: Risk/Ton	Without Project: Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	With Project: Total Risk	Reduction in Risk (000)
Year 1985									
10-29,000	10	34.3	0	-	0	0	0	-	
30-39,000	20	68.6	0	-	15	51.5	0	-	
40-49,000	20	68.6	.07	4.8	15	51.5	.04	2.1	
50-59,000	50	171.5	.14	24.0	70	240.1	.07	16.8	
TOTAL	100			28.8	100			18.9	9.9
Year 1995									
10-29,000	10	32.8	0	-	0	0	0	-	
30-39,000	20	65.6	0	-	15	49.2	0	-	
40-49,000	20	65.6	.07	4.6	15	49.2	.04	2.0	
50-59,000	50	164.0	.14	23.0	70	229.6	.07	16.1	
TOTAL	100			27.6	100			18.1	9.5

*All Foreign traffic

Table 15
Computation of Annual Risk Benefits
for LPG*

DWT Group	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume	Without Project: Risk/Ton	Without Project: Total Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	With Project: Total Risk	Reduction in Risk
				Year 2005, 2015					
10-29,000	10	32.8	0	-	0	0	0	-	
30-39,000	10	32.8	0	-	15	49.2	0	-	
40-49,000	20	65.6	.07	4.6	15	49.2	.04	2.0	
50-59,000	60	196.8	.14	27.6	70	229.6	.07	16.1	
TOTAL	100			32.2	100			18.1	14.1
				Year 2025, 2035					
10-29,000	5	16.4	0	-	0	0	0	-	
30-39,000	10	32.8	0	-	15	49.2	0	-	
40-49,000	25	82.0	.07	5.7	15	49.2	.04	2.0	
50-59,000	60	196.8	.14	27.6	70	229.6	.07	16.1	
TOTAL	100			33.3	100			18.1	15.2

*All foreign traffic

Table 15
Computation of Annual Risk Benefits for Dry Bulk-Foreign Traffic

1985-2035

DWT Group (000)	Without Project: Tonnage Carried Percent	Without Project: Tonnage Carried Volume (000)	Without Project: Risk/Ton	Without Project: Risk	With Project: Tonnage Carried Percent	With Project: Tonnage Carried Volume	With Project: Risk/Ton	With Project: Risk	Reduction in Risk (000)
20	12	52.1	0	-	12	52.1	0	-	
30	40	175.0	.36	63.0	40	175.0	.18	31.5	
40	48	208.3	.72	150.0	48	208.3	.36	75.0	
TOTAL:		435.4		213.0		435.4		106.5	106.5

Table 16

SUMMARY OF RISK BENEFITS ($000)

YEAR	PETROLEUM	LPG	DRY BULK	TOTAL
1985	492.9	9.9	106.5	609.3
1995	483.7	9.5	"	599.7
2005	491.3	14.1	"	611.9
2015	491.3	14.1	"	611.9
2025	492.2	15.2	"	613.9
2035	492.2	15.2	"	613.9
	Average Annual Equivalent:			605.9

Project Use With and Without Improvements

As previously noted, petroleum products comprise the vast majority of tonnage at Portsmouth. Without project improvements the average size of ships carrying these products will increase only very slowly. With project improvements better safety will stimulate immediate greater usage of vessels in the 35-45,000 DWT range.

Structural modifications at the harbor are not expected to alter the anticipated level of petroleum receipts. Other factors appear to have a greater influence on the amount of petroleum to be transported. Energy conservation and conversion are among the chief factors which are expected to cause petroleum tonnage to decline after 1990.

The conversion from petroleum products to coal will alter shipping operations at Portsmouth to some degree. Granite State Minerals Corporation is making plans to receive coal using two 30,000 ton barges. Also, Public Service Company of New Hampshire which uses the Sprague Terminal may bring coal into Portsmouth. Public Service has two power plants in the Portsmouth Area - Schiller Station and Newington Station. Schiller Station was a coal-fired plant at one time, but has been converted to petroleum.

This station may be reconverted to coal. It is anticipated that 30,000 ton barges or colliers with drafts of 25-30 feet would be used to supply the product. Although structural modifications to the channel would benefit coal vessels from a safety standpoint, it is not anticipated that transportation costs would be reduced.

With or without harbor improvements it is expected that movement of products other than petroleum will continue to exhibit steady growth. A new asphalt facility recently became operational. At the New Hampshire State Port Authority facility exports of bagged sugar are increasing. Movement of scrap metal and steel rails continues to grow. Also, a new State-owned and operated fish pier has resulted in increased fish shipments. Commodities such as wood, liquor, bricks, and apples may also be transported. Future plans call for further expansion of the State Port Authority facility by the addition of two wharves, a gantry crane, refueling capacity, and a set of berths for commercial fishing craft. The New Hampshire Legislature has allocated money for a roll on-roll off facility to be designed. A container feeder service was also started in Portsmouth in 1980. The feeder vessel stops in Portsmouth once a week and makes trips to Providence, Boston, and Halifax before sailing to Europe. It is anticipated that this service will continue to operate.

Structural channel modifications would improve safety for carriers of non-petroleum commodities. This would provide an additional incentive for manufacturers and traders to locate in Portsmouth and for shippers to use the harbor to a greater extent. Although it is reasonable to assume that harbor use would be promoted by the improvements, potential transportation savings for commodities other than petroleum and salt were not substantiated.

ECONOMIC JUSTIFICATION

To be considered economically justified, a project must have a benefit/cost ratio of one or greater. The benefit/cost ratio for the NED plan (benefits shown in Table 17) is as follows:

Annual Benefits	Annual Costs	BCR	Net Benefits
2,532.7	1,661.0	1.5	871.7

TABLE 17

Summary of Benefits ($000)

Transportation Cost Savings	
Channel Modifications and Emergency Maneuvring Area	
Petroleum	$1,830.9
Salt	47.9
Operational Savings	
Emergency Manuevering Area (Salt and Scrap Iron Vessels)	48.0
Reduction in Risk	
Petroleum	499.4
Dry Bulk (Salt and Scrap Iron)	106.5
TOTAL BENEFITS	2,532.7

Sensitivity Analysis

In order to deal with risk and uncertainty relating to commodity projections a sensitivity analysis was undertaken. The analysis investigates the effects on economic justification of a change in the commodity outlook. As previously discussed, the most probable future scenario calls for growth in the level of most petroleum receipts until 1990, when a decline caused by conservation and conversion is expected to occur. Crude petroleum receipts are assumed to continue to grow until refinery plant capacity is reached. The forecast for salt imports calls for a leveling off beginning in 1985.

The sensitivity analysis tests the impact on project benefits of a lower level of projections. Under this analysis the benefits for the structural alternatives are computed using actual 1978 tonnage figures assuming no growth in tonnage over the project lifetime.

The methodology used in the computation of benefits is identical to the methodology used in developing Table 13. Utilization of the assumptions of the sensitivity analysis results in an annual benefit figure of $2,123,400. The respective benefit cost ratio 1.3 is 1.

APPENDIX E

ENVIRONMENTAL STUDIES

Homerus americanus (American Lobster)
SURVEY OF THE PISCATAQUA RIVER

PORTSMOUTH HARBOR AND PISCATAQUA RIVER
MAINE AND NEW HAMPSHIRE
NAVIGATION IMPROVEMENT
GENERAL DESIGN MEMORANDUM

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CORPS OF ENGINEERS
OCTOBER 1985

INTRODUCTION

The species of the families Nephropidae (clawed lobsters) and Palinuride (spiny lobsters) support some of the most valuable fisheries in the world. The catch per unit effort for many lobster fisheries has declined markedly, while the demand and monetary value of the catch increases. These trends have intensified interest in learning more about the habitat requirements, population ecology, and behavior of the species so that these effects on the fishery can be evaluated for effective management including protection of species. While ecological knowledge of lobsters is substantial, it is far from being as comprehensive as it should be.

Both an inshore and an offshore fishery operate in the United States. The inshore fishery is limited to a depth of about 40m and operates from Maine to Delaware. Landings in 1983 were on the order of 20 million pounds worth approximately $41 million dock side in Maine. This represents approximately 40% of the dollar value of all Maine Marine Fisheries. The inshore fishery is active throughout the year, but the fishing effort is usually restricted by adverse weather conditions during the winter months.

Inshore populations of Homerus americanus (American lobster) consist of local groups; it is generally believed that these groups are reproductively isolated. The lobster is found on mud substrates mixed with solid objects (at depths from 5-15 meters in harbors and estuaries on the Maine coast in densities of juveniles up to $20/m^2$ (Cooper & Uzmann, 1977) inshore sandy substrates with overlying flattened rocks support the greatest concentrations of lobster of 3.25 individuals/m^2 (Cooper et al 1975; Cooper and Uzmann, 1977).

McLeese (1956) demonstrated that the effects of temperature, salinity, and oxygen are interdependent. Tolerance to extremes of any of these factors singly or in combination is enhanced by prior acclimation or physiological conditioning. He found the following ranges of tolerances: temperatures from $1.8^{o}c$ to $30.5^{o}c$; dissolved oxygen from 0.20 mg/l ($5^{o}c$ & 30% salinity) to 1.72 mg/l ($25^{o}c$ & 20% salinity); salinity as low as 6.0% (with 5^{o} & 6.4 mg/l).

The preceding discussion was based on the text entitled, "The Biology and Management of Lobsters", Volumes I and II, edited by J. Stanley Cobb and Bruce F. Phillips (1980). With the latest physical environmental information on the Piscataqua River, there is a potential for lobsters to be present in the proposed project area year round. (See main report, page 10.) The temperature range is from 2^{o} to $15^{o}c$. Salinity ranges from 26.6ppt to 31.8ppt. The bottom is a uniform slope consisting of mud/sand with some gravel. The bottom currents were recorded up to 1.55 meters per second (3.02 knots) (HELTZEL, Personal Communication). As noted from the information above all of these perimeters are within the tolerance range of lobsters.

The decision was made to undertake a diving H americanus (American lobster) survey of the entire proposed dredging area, because of a requirement of the Federal Consistency Concurrence and Water Quality Certification for State of Maine and the potential for construction activities to impact the resident population.

METHODS

Two (2) diver-biologists swam a two (2) meter wide transect recording all H americanus (both juvenile and adult lobsters) and their location along the transect. A total of 30 transects were surveyed during daylight hours at slack tide over a four (4) day period (4 to 8 September 1985). These transects represented over 6.0% of the total area proposed to be dredged.

The thirty (30) transects were located using a random number generator program from a Texas Instruments (TI) Programmable 59 Calculator. Eight (8) transects were located near Goat Island, varying in depth from -6.096m to -18.288m (-20 feet to -60 feet), with transect lengths from 36.576m to 48.768m (120 feet to 160 feet); and twenty-two (22) transects are located near Badgers Island, varying in depth from -0.9144m to -16.764m (-3 feet to -55 feet), with transect lengths from 36.576m to 118.872m (120 feet to 390 feet). The need to survey thirty (30) transects was based on the following assumptions:

a. Slope and substrate are more or less uniform;

b. Lobster densities are similar to those of populations found in the Kennebunk River mouth;

c. The sample method is adequate and possible;

d. The lobster population consists of local groups with seasonal movement (highest numbers found in late summer, lowest numbers found in early spring);

e. Preconstruction survey results would be applicable during construction time;

f. The Sokal & Rohlf's method of number of replications needed to detect a given "true" difference between means (Page 263) is appropriate (Sokal & Rohlf, 1981);

g. Single classification Model I Anova assumptions are valid;

h. Significance level of 0.05 is adequate.

In addition to recording number and location (3 divisions of each transect) of H americanus, observed size: (subjective grouping under: 223.92g (0.5 lb.), 223.92g to 453.64g (0.5 lb. to 1.0 lb., and over 453.64g (1 lb.), behavior (hiding vs. moving) and general physical and biological habitat information was recorded (e.g. substrate type, organisms and algae present, etc.).

The following physical parameters were recorded for each transect: bottom salinity, bottom water temperature, dissolved oxygen, pH, conductivity, estimated bottom current and direction, and bottom visibility. These parameters were recorded using a hydrolab model 4000, except bottom current and visibility were estimated by divers.

A single classification model I Anova was run using a T.I. Solid State Software Applied Statistics Module.

RESULTS

As shown in Table 1, a total of 221 individuals were collected from the 30 transects with numbers ranging from 0 to 19 per transect. The transects with the highest numbers of lobster were located at the up-river end of the proposed dredge area at Goat Island (Transects 7 and 8) with 19 and 17 individuals respectively. The means ranged from 3.0 to 15.0 with standard deviation from 0.0 to 25.6667. The densities ranged from 0.0126 to 0.0984 individuals per square meter. The individuals recorded in each of the size ranges were: under 223.92g (68 individuals); between 223.92g and 453.64g (100 individuals); and over 453.64g (50 individuals). The individuals were uniformly spaced along the transects (Table 3.).

The physical parameters were consistent throughout the survey (Table 2): current 25.72 to 102.88 cm/sec; visibility 3.048 to 6.096 meters; depth 0.9144 to 18.288 meters; conductivity 48,600 to 49,800 $\pm$ 200 MMHO/CM; salinity 31.5 to 32.5; temperature 17.5 to 17.9 C^{o}; D.O. 7.1 to 7.9 MG/L; pH 7.6 to 7.9; and bottom type mostly rock and cobble.

At Goat Island the Biota consisted mostly of: Tubularia larynx (Hydroid), Clioma celata (boring sponge), Halichondria panicea (sponge), Cancer borealis (rock crab) Asterias vulgaris (purple starfish), Henricia sanguinolenta (bloodstars) with a dense algal cover of: Chondrus crispus (Irish moss), Gigartina stellata (red algae), Rhodophyllis dichotoma (red algae), Laminaria saccharina (brown algae), and L digitalis (brown algae).

At Badgers Island sandy patches were present on the bottom. This was reflected in the biota present: Pseudopleuronectes americanus (winter flounder), Tautogolabrus adspersus (cunner), Cancer irroratus (rock crab), Lunatia heros (moon snail), Limulus polyphemus (crab) and Zostera marina (eel grass). Mytilus edulis (blue mussel) were present on three transects with a bed present only along one. Modiolus modiolus (horse mussel) were present on only one transect. Cardinides maenas (green crab) were abundant in this area. Several M edulis (mussel) clumps were physically destroyed to determine the number of H americanus (juvenile lobsters) present. No individuals were found. It is suspected that the C magnas (which are very abundant) are feeding on the juvenile lobsters. In high numbers, these crabs can completely remove the population very small lobsters. A complete species list is present in Table 4.

The area at Goat Island was considered by the divers as excellent lobster habitat with numerous holes and good algae coverage in which to hide and forage. The area at Badgers Island appeared to be limited as lobster habitat with the exception of the down river end of the area. This reach appeared to the divers as excellent lobster habitat.

DISCUSSION

The intent of this survey was to determine the highest H americanus (American lobster) density at the two proposed dredging areas (Goat Island and Badgers Island). As can be seen from the Methods Section, care was taken to observe to the maximum extent possible all lobsters. The divers indicated that the area at Goat Island is excellent habitat. The area at Badgers Island is limited in habitat, but does offer excellent habitat at the down river end. All physical parameters indicate lobster numbers should have been at their highest during the survey. All biological data collected indicated that there exists good algal cover and the habitat is a productive community.

The State of Maine placed a requirement on the Federal Consistency Concurrence and Water Quality Certification that a survey be undertaken for H americanus, and if the density is higher than one per square meter, they are to be transplanted. As can be seen in Table 1, a total area of 4078.224 M^2 was surveyed. A total of 221 individuals were recorded. The mean densities are very low with the highest being 0.1640 per square meters on the 36.576 M long transects. The standard deviation was very high 0.2939, but still below one individual per square meter.

The Anova results indicate that there is a significant difference between the groups; meaning that the lobsters are not randomly distributed. This may be due to the micro-habitat conditions within the survey area. As noted by the divers, some transects had limited habitat value.

REFERENCES

1. COBB, J.S. and B.F. PHILLIPS (1980), The Biology and Management of Lobsters VOL. I AND II, Academic Press, New York, NY

2. SOKOL, R.R. and F.J. ROHLF (1981), Biometry, Freeman and Co., New York, NY, 859 pp.

3. U.S. ARMY CORPS OF ENGINEERS (1984) Portsmouth Harbor & Piscataqua River, NED Waltham, MA

TABLE 1

NUMBERS OF *H. americanus*

TRANSECTS (Area in Square Meters)

	73.152	91.44	97.536	146.304	158.496	164.592	182.88	219.456	237.744
	12	16	9	1	15	6	3	3	4
	10	8		5			3	4	3
	17	6						5	2
	9	19							3
		12							
		5							
		9							
		13							
		8							
		4							
		0							
		8							
TOTAL	48	108	9	6	15	6	6	12	12
$\bar{x}$	12	9.0	9.0	3.0	15.0	6.0	3.0	4.0	3.0
s	9.5	25.6667	0.0	4.0	0.0	0.0	0.0	0.6667	0.5
$d_{\bar{x}}$	0.1640	0.0984	0.0923	0.0203	0.0946	0.0364	0.0164	0.0182	0.0126
d_s	0.2939	0.3791	0.0923	0.0273	0.0946	0.0364	0.0164	0.0213	0.0147

TOTAL: $\bar{x}$ 7.3667
s 24.0989
$d_{\bar{x}}$ 0.0054
d_s 0.0229

Individuals 221
Area 4078.224m^2

df 7.0/21.0
SS(E) 358.0
SS(T) 363.0345
SS(Total) 721.0345
F 3.0422
$0.01 < P < 0.025$

TABLE 2

PHYSICAL DATA

TRANSECT	CURRENT (Kt)	VISIBILITY (meters)	DEPTH (meters)	CONDUCTIVITY (mmho/cm)	SALINITY (ppt)	TEMP. (C°)	D.O. (mg/l)	pH	BOTTOM TYPE
1	0.5	3.0	10.0-15.2	49,600±200	32.5	17.6	7.6	7.9	rocks/cobble
2	1.0	3.0	7.3-18.3	49,300±200	32.0	17.5	7.4	7.8	rocks/sand
3	1.5	3.0	7.0-16.8	49,300±200	32.5	17.5	7.8	7.6	rocks/sand
4	1.5-2.0	3.0	7.0-12.2	49,400±200	32.5	17.5	7.4	7.7	rocks
5	1.0	3.0	7.6-13.7	49,390±200	32.0	17.5	7.8	7.6	rocks/sand
6	<0.5	6.0	9.1-16.8	49,200±200	32.0	17.6	7.9	7.6	rocks
7	<0.5	6.0	6.1-16.8	49,300±200	32.0	17.6	7.3	7.7	rocks/sand
8	1.5-2.0	3.0	6.7-13.7	49,200±200	32.0	17.6	7.1	7.7	rocky
9	<0.5	6.0	3.0-13.7	48,600±200	31.5	17.7	7.5	7.7	rocks/rocky
10	>1.0	3.0	4.0-12.2	48,600±200	31.5	17.7	7.5	7.7	rocks
11	<1.0	15.0	3.7-13.7	48,600±200	31.5	17.9	7.4	7.7	rocks
12	0.5	15.0	6.1-10.7	48,600±200	31.5	17.8	7.4	7.6	rocky
13	<0.5	6.0	6.4-13.7	48,600±200	31.5	17.8	7.4	7.6	rocks
14	1.0	4.6	6.7-13.4	48,600±200	31.5	17.8	7.4	7.6	rocky/sand
15	1.0	3.0-4.6	6.4-13.7	48,600±200	31.5	17.8	7.4	7.6	cobble/sand
16	<0.5	6.0	3.7-14.0	48,600±200	31.5	17.8	7.4	7.6	rocks/sand
17	<0.5	6.0	3.7-14.6	48,600±200	31.5	17.8	7.4	7.6	cobble/sand
18	0.5	4.6	3.0-12.8	48,600±200	31.5	17.8	7.4	7.6	cobble/sand
19	<0.5	6.0	1.5-10.7	48,600±200	31.5	17.8	7.4	7.6	cobble
20	<0.5	6.0	1.5-12.2	48,800±200	31.75	17.7	7.9	7.6	cobble/sand
21	<0.5	6.0	1.5-13.7	48,800±200	31.75	17.7	7.9	7.6	sand
22	<0.5	6.0	1.5-13.7	48,800±200	31.75	17.7	7.2	7.6	cobble
23	<0.5	6.0	1.5-13.7	48,700±200	31.75	17.8	7.2	7.7	cobble/sand
24	<0.5	6.0	1.5-16.8	48,600±200	31.5	17.7	7.5	7.7	cobble/clay
25	<0.5	6.0	1.5-16.8	48,700±200	31.75	17.8	7.2	7.7	shell/sand
26	<0.5	-	0.9-15.2	48,600±200	31.5	17.7	7.5	7.7	rock/sand
27	<0.5	6.0	6.1-10.7	48,600±200	31.5	17.8	7.2	7.7	rocks/cobble
28	-	4.6	9.8-16.8	48,600±200	31.5	17.7	7.5	7.7	cobble
29	0.5	4.6	9.1-16.8	48,600±200	31.5	17.7	7.5	7.7	rocks/cobble
30	<0.5	6.0	7.9-13.7	48,600±200	31.5	17.7	7.5	7.7	rocks/cobble

TABLE 3

HOMARUS AMERICANUS

	LOBSTERS PER SIZE GROUPING			LOCATION OF LOBSTERS ALONG TRANSECT			TOTAL NO. OF LOBSTERS	TRANSECT LENGTH (Meters)
	<0.5 lb	0.5-1.0 lb	>1 lb.	A	B	C		
1	4	6	2	5	3	4	12	36.576
2	5	9	2	5	6	5	16	45.72
3	2	5	1	5	-	3	8	45.72
4	2	4	2	4	2	2	8	45.72
5	4	4	2	4	4	2	10	36.576
6	-	2	4	3	1	2	6	45.72
7	3	10	6	5	10	4	19	45.72
8	15	-	2	5	5	7	17	36.576
9	2	6	0	7	1	1	9	48.768
10	-	-	-	-	-	-	0	45.72
11	1	2	1	2	1	1	4	45.72
12	1	4	3	3	2	3	8	45.72
13	8	4	1	6	4	3	13	45.72
14	2	5	2	5	2	2	9	45.72
15	-	3	2	2	2	1	5	73.152
16	3	10	2	5	5	5	15	79.248
17	2	1	-	3	-	-	3	91.44
18	1	3	1	3	1	1	5	109.728
19	-	2	1	1	1	1	3	118.872
20	1	1	-	2	-	-	2	118.872
21	2	1	-	2	1	-	3	118.872
22	1	1	2	3	1	-	4	118.872
23	-	3	1	4	-	-	4	109.728
24	1	1	1	3	-	-	3	109.728
25	1	2	-	3	-	-	3	91.44
26	2	2	2	3	3	-	6	82.296
27	-	1	-	1	-	-	1	73.152
28	3	-	2	3	-	2	5	45.72
29	6	4	2	4	-	8	12	45.72
30	1	3	5	5	2	2	9	36.576

TABLE 4 FLORA AND FAUNA

SCIENTIFIC NAME	COMMON NAME
PLANTS	
Zostera marina	Eel grass
ALGAE	
Laminaria digitata	
Laminaria saccharina	Brown algae
Condrus crispus	Irish moss
Ulva lactuca	Green algae
Agardiella Sp.	Red algae
Chaetomopha Sp.	Green algae
Laminaria Sp.	
Desmorestia Sp.	
Eudesme Sp.	
Rhodophyllis dichotoma	
Punctoria Sp.	
Gingartina stellata	
Membranoptera Sp.	
Laminaria digitalis	Kelp
Ascophyllum Sp.	Brown algae
Fucus Sp.	Brown algae
INVERTEBRATES	
Tubularia larynx	Hydroids
Halichondria panicea	Sponge
Asterias vulgaris	Purple seastar
Henricia sanguinolenta	Bloodstar
Cancer borealis	Rock crab
Cerianthus borealis	Sand worm
Metridium senile	Sea anemone
Amaroucium Sp.	Ascidian
Cliona celata	Boring sponge
Cancer irroratus	Rock crab
Isodictya Sp.	Palmate sponge
Littorina littorea	Periwinkle
Lunatia heros	Moon snail
Mytilus edulis	Blue mussel
Strongylocentrotus droehbachiensis	Urchins
Henricia Sp.	Blood star
Ensis directus	Razor clam
Carcinides maenas	Green crab
Carcinus polyphemus	Horseshoe crab
Bugula turrita	Bryozoan
Modiolus modiolus	Horse mussel
Pagurus longicarpus	Hermit crabs
Halichondria Sp.	Sponge
Tautogolabrus adspersus	Cunner

INVERTEBRATES (cont'd)

<u>Raja</u> <u>ocellata</u>	Skate
<u>Pseudopleuronectes</u> <u>americanus</u>	Winter flounder
<u>Pholis</u> <u>gunnellus</u>	Rock Eel
<u>Pollachius</u> <u>virens</u>	Polluck
<u>Hemitripterus</u> <u>americanus</u>	Sea raven
<u>Gadus</u> <u>morhua</u>	Codfish

APPENDIX F

ENGINEERING CONSIDERATIONS

PORTSMOUTH HARBOR GDM
APPENDIX F
ENGINEERING CONSIDERATIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

APPENDIX F

ENGINEERING CONSIDERATIONS

DESIGN AND COST ESTIMATES

Introduction. This appendix presents engineering data in support of the selection of the recommended plan of improvement. For clarity the analysis is divided into two parts: Engineering Design and Cost Estimates.

SECTION A - ENGINEERING DESIGN

General. Modifications to the general navigation facilities, considered in this report, have been designed in accordance with criteria contained in Engineering Regulation (ER) 1110-2-1404 entitled "Deep Draft Navigation Project Design" dated September 24, 1981; Engineer Manual (EM) 1110-2-1613 entitled "Hydraulic Design of Deep Draft Navigation Projects" dated April 8, 1983; a ship simulation model study entitled "An Evaluation of the Effectiveness of a Proposed Channel Design Modification for Navigation Risk Mitigation in Portsmouth Harbor" dated August 1985; and input from the Portsmouth Harbor Pilots.

VESSEL ANALYSIS

Introduction. Tankers have for many years, played a critical role in the worldwide distribution of energy. The events in recent years have focused attention on the tankers and their importance in maintaining the lifestyle of people all over the world. In the case of New Hampshire, Portsmouth Harbor is the only deep draft harbor in the State capable of handling these large vessels. Defense installations, utility companies and industrial complexes depend upon the ability of the harbor to provide for the safe transport of petroleum products. The following analysis is intended to provide a forecast of the range of ship sizes, especially tankers, expected to service Portsmouth Harbor over the economic life (1985-2035) of proposed navigation improvements.

Forecast World Fleet Serving U.S. Trade 1/

The number of vessels in the world fleet required to serve the U.S. foreign trade, which includes U.S. flag vessels, is projected to grow by only 379 vessels or about 10 percent between 1975 and 2000 (see Table 1). In this period, trade is projected to increase over 130 percent. The trend to larger and more efficient vessels is reflected by the growth in deadweight of nearly 90 percent.

1/ U.S. Department of Commerce, Maritime Administration, Office of Commercial Development, Summary Report, dated May 1978.

New construction activity over the forecast period will be a function of two key factors: world trade growth and replacement requirements resulting from scrapped vessels. These factors combine during the forecast period in such a way that shipbuilding activity required to support U.S. - foreign trade is projected to decline substantially in the 1980's. This is consistent with the current shipbuilding outlook.

Table 1

MERCHANT FLEET FORECAST SUMMARY
TOTAL SHIPS REQUIRED TO SERVE THE U.S.-FOREIGN TRADE
(vessels and thousands of deadweight tons)

	1975	1980	1985	1990	1995	2000
			VESSELS			
General Cargo Ships	2,043	1,867	1,647	1,346	1,044	795
Partial Containerships	132	247	373	555	754	1,043
Full Containerships[1]	181	259	303	365	429	511
Barge Carriers	27	23	29	33	37	40
Neobulk Carriers	80	101	126	153	176	205
Dry Bulk Carriers	860	905	960	991	1,038	1,080
Combination Carriers	82	98	106	110	113	124
LNG Carriers	1	11	42	58	72	82
Tankers	643	805	772	748	710	548
Total	4,049	4,317	4,357	4,359	4,374	4,428
		1,000s OF DEADWEIGHT TONS				
General Cargo Ships	18,241	18,288	16,634	14,496	11,754	9,387
Partial Containerships	1,387	3,011	4,950	7,860	11,468	16,365
Full Containerships[1]	2,766	4,198	5,086	6,307	8,058	10,180
Barge Carriers	1,015	896	1,160	1,336	1,520	1,721
Neobulk Carriers	1,730	2,193	2,779	3,487	4,298	5,428
Dry Bulk Carriers	26,278	28,340	31,692	34,691	39,482	46,550
Combination Carriers	5,837	7,275	8,463	9,631	11,128	13,090
LNG Carriers	32	608	2,394	3,316	5,000	6,185
Tankers	27,976	45,118	50,528	53,787	56,247	50,887
Total	85,262	109,928	123,685	134,909	148,956	159,793

[1] Includes Ro-Ro vessels.

Note: Totals may not add due to rounding

However, in the 1990s the combination of trade growth and vessel retirements is expected to result in a significant rise in construction activities.

Specific findings regarding the world fleet include:

In every ship type, increasingly Larger vessels will be built. The largest increases will occur in LNG carriers and tankers which are expected to increase in average size by 133 percent and 113 percent, respectively. The smallest increase, 14 percent will occur in barge carriers. The average increase in deadweight tonnage per vessel for the whole fleet is 71 percent.

There will be an increasing reliance on more sophisticated liner type vessels in the future. During the next 25 years the number of partial containerships will increase nearly eightfold, while the number of full containerships will nearly triple. The number of general cargo ships is projected to decrease over the same period by 60 percent.

Forecast - U.S. Flag Fleet.

The development of the U.S.-flag merchant fleet will depend on many factors such as management skills of U.S. flag vessel operators, capacity of U.S. shipyards, policies of the Maritime Administration, and Federal legislation. In the long run, a strong influence on the size of the U.S. flag merchant fleet may be caused by an additional factor, the worldwide trends towards national flag preference. The Merchant Marine Act of 1970 provides for a subsidy program. While it cannot be determined with certainty what type of subsidy program will be enacted for the period 1985-2035 (economic life expectancy of this report's improvement proposal), it appears reasonable to assume that the Federal Government will continue to provide the necessary support to the U.S. Merchant Marine.

Accordingly, if the forecasted U.S. flag share levels for a medium growth scenario are achieved, the number of vessels in the fleet would increase by nearly 200. This equates to a 75 percent increase in the number of vessels in the fleet and a 108 percent increase in deadweight tonnage. A medium scenario forecast of U.S. flag vessels is shown in Table 2.

Findings regarding the U.S. flag fleet include:

The U.S. flag fleet reflects a substantially different profile than the world fleet. The differences are most apparent when viewed in the context of liner type vessels (general cargo, partial and full container, and barge carrying ships) and non-liner type vessels (neobulk and dry bulk carriers, combination carriers, LNG carriers, and tankers). The number of these non-liner type vessels is projected to more than triple and on a deadweight basis to increase sixfold by the year 2000.

Table 2

MERCHANT FLEET FORECAST SUMMARY
U.S.-FLAG VESSELS ENGAGED IN U.S.-FOREIGN TRADE

Medium Scenario
(vessels and thousands of deadweight tons)

	1975	1980	1985	1990	1995	2000
			VESSELS			
General Cargo Ships	106	81	77	37	18	19
Partial Containerships[1]	20	20	28	41	55	71
Full Containerships[1]	58	69	77	97	126	156
Barge Carriers	23	19	22	24	26	27
Neobulk Carriers	0	0	2	4	6	9
Dry Bulk Carriers	3	7	18	30	42	56
Combination Carriers	2	2	3	3	4	4
LNG Carriers	0	6	23	31	39	44
Tankers	38	48	48	53	56	56
Total	251	252	298	320	372	442
			DEADWEIGHT			
General Cargo Ships	1,402	1,057	1,021	513	249	269
Partial Containerships[1]	265	269	389	569	769	999
Full Containerships[1]	1,112	1,353	1,568	1,966	2,600	3,228
Barge Carriers	839	720	866	954	1,051	1,149
Neobulk Carriers	6	6	34	76	134	224
Dry Bulk Carriers	91	255	623	1,041	1,575	2,330
Combination Carriers	172	171	223	283	318	350
LNG Carriers	0	346	1,325	1,786	2,673	3,265
Tankers	1,762	4,211	4,646	5,531	6,201	6,606
Total	5,650	8,380	10,695	12,719	15,570	18,420

[1] Includes Ro-Ro vessels.

Note: totals may not add due to rounding

U.S. flag vessel new constructions are projected to increase over the forecast period. In the 1976-1980 time period, construction was expected to average about 11 vessels per year. This figure will exceed 25 per year by 2000 if the projected U.S. flag share is achieved.

Summary Table 3 (U.S. Liquid Bulk Carriers - Atlantic Coast) presented below shows that by the year 2000, 37 percent of the vessels utilized in the liquid bulk trade for the Atlantic Coast are expected to be in the 30,000 to 50,000 DWT size range. The average loaded draft of this range of tankers is 37 feet.

The above tabulation seems to be borne out somewhat by recent reports of the Sun Shipbuilding and Drydock Company. Excerpted data from the 1975 and 1976 reports show the average deadweight tonnage of the U.S. flag fleet to have increased from 22,100 DWT in 1966 to 36,200 DWT in 1975 to 39,900 DWT in 1976. The average DWT of U.S. flag vessels under construction or on order in 1976 was 119,432.

C. Characteristics.

In recent years, the need for and use of proper vessel design characteristics in project formulation studies has become increasingly important. In the future, petroleum products and tankers will continue to form an integral part of any proposed deep draft harbor improvement.

Past investigations have relied principally on typical vessel characteristics. Although considered representative of the average characteristics for various types of deep draft vessels comprising the world fleet, these data lacked statistical verification. With this in mind, the Corps' Mobile District Office (MDO) conducted an independent investigation of bulk carriers and tankers in the 1976 world fleet to ascertain whether more reliable data could be developed regarding physical characteristics and dimensions for deep draft vessels. Results of their investigation have been documented in a report entitled, "Statistical Analysis of Vessel Characteristics for Dry Bulk Carriers and Tankers in the 1975 World Fleet" dated 2 January 1977. Data contained in the report are considered statistically reliable estimates of selected ship characteristics, including draft, tons per inch of immersion, deadweight tonnage, speed, length, breadth, and gross registered tonnage.

In the case of Portsmouth Harbor, proposed project dimensions have been based, in large measure, on the expected use of 30,000 to 45,000 DWT vessels, representing the average range of vessel sizes. The characteristics of the range of tankers have been excerpted from the Mobile District Office analysis and are shown on Table 4 below. Additional information on vessels is presented in the Economics Appendix.

Table 3

U.S. LIQUID BULK CARRIERS - ATLANTIC COAST

DWT (000)	PERCENT OF TOTAL FLEET* 1975	1980	1985	1990	1995	2000
1-10	2	2	2	2	2	1
10-20	2	2	4	3	5	5
20-30	37	36	28	29	29	25
30-50	42	41	37	36	38	37
50-70	9	9	19	15	14	15
70-125	7	9	9	8	5	5
125-175	0	0	1	7	7	12
175-225	0	0	1	3	5	7
225-300	0	0	0	2	2	1
300+	0	0	0	0	0	3
30-50 & Up Totals	58	59	65	59	57	57

*Excerpted Data from "A Study of the Future Requirments for Ships That Will Be Engaged in the U.S. World Trade for Both the Short and Long Term" - 1976 - By Temple, Barker, and Sloane, Inc.

Table 4

SIZE RANGE AND CHARACTERISTICS OF VESSELS
EXPECTED TO UTILIZE PORTSMOUTH HARBOR

Vessel Size DWT-Range	Av. DWT	Loaded Draft	Length	Beam
27,500-32,500	30,000	34	607	83
37,500-42,500	40,000	37	653	91
42,500-47,500	45,000	38	673	94
47,500-52,500	50,000	40	702	97

GENERAL NAVIGATION FACILITIES

Channel Depths. The design channel depth for the existing waterway and turning basin is based on the static loaded drafts of the range of vessels expected to transit the waterway and consideration of the following factors required for safe vessel operation:

a. Clearance. A vessel must have sufficient water under the keel to allow for safe and efficient maneuvering when operated under its own propulsion. Two feet of clearance under keel are required for channels constructed in soft material. Where rock is present in the channel, an additional 2-foot clearance is provided for safety.

b. Squat and trim. A vessel in motion will squat or sink in the water, depending on: (1) the vessel speed, (2) distance between keel and channel bottom, (3) trim of the vessel, (4) cross-sectional area of the vessel, (5) whether the vessel is passing another large vessel, (6) location of the vessel relative to the channel centerline, and (7) general characteristics of the vessel. The trim of a vessel refers to the angle of the bottom of the vessel with respect to the water surface. Vessels are trimmed during loading so that a level keel can be established at a later period during the voyage as fuel and water are used. Because of the slow or dead slow speed of the vessels, no allowance was made for squat and trim.

c. Tidal phenomena. Vessels using Portsmouth Harbor are able to take advantage of a 8.4 foot mean range of tide throughout the year. By allowing for smaller than average tides and a 2-hour period prior to high tide, computations were made using a 6-foot tidal advantage under design conditions.

d. Loss in buoyancy. The lower density of freshwater relative to saltwater results in a loss of buoyancy as a vessel moves from the ocean into the harbor. The brackish transition zone from fresh to saltwater is located well above the head of the authorized 35-foot project. Therefore, no allowance is needed for vessels transiting the existing waterway.

e. Wave action. Waves or swells are often present in the Sound and harbor. Wave forces result in the vertical vessel motions of heave, pitch, and roll, and must be considered in determining the necessary channel depth. The motion of heave raises and lowers the entire vessel with relation to the stillwater level. The motion of pitch alternately thrusts the bow and stern of the vessel above and below the stillwater level. The motion of roll alternately raises and lowers one side of the vessel with relation to the keel or bottom centerline of the vessel. While vessels navigating the channel do encounter waves. They have almost no effect on large ocean-going vessels. Hence, allowance for vessel pitch, roll and heave due to wave forces are considered unnecesary.

f. Summary. Exhibit 1 illustrates the criteria used in determining available channel depth and design vessel draft for Portsmouth Harbor. The design draft was determined as follows:

Channel Depth at MLW	35 feet
Tidal Effect	6 feet
Available Depth	41 feet
Clearance Requirements	4 feet
Operating Draft	37 feet

Based on an operating draft of 37 feet and the vessel characteristics in Table 4, the selected design vessel is a 40,000 DWT vessel with a loaded draft of 37 feet, length of 653 feet and a beam of 91 feet.

Channel Widths. The design width of the Portsmouth Harbor channels is based on the traffic density, beam and steering characteristics of vessels expected to transit the waterway, and consideration of currents, wave conditions, winds, bends, and general alignment. Channel widths are measured at the design channel depth (bottom width).

a. The selected channel width must be sufficient to allow adequate control of vessels using the waterway under expected conditions of ship speed, currents, channel alignment and traffic.

Table 5

PROPOSED CHANNEL WIDTH

LOCATION	MANEUVER LANE (feet)	BANK CLEARANCE LANE (feet)	TOTAL CHANNEL WIDTH (feet)
Area 1 bend	455	135 x 2	725
Area 3 bend	80	135 x 2	550

b. For one-way traffic, the considered design condition for Portsmouth Harbor, the channel width is divided into three parts: a vessel maneuvering lane, and bank-clearance lanes, one on either side of the vessel, between the outer edges of the maneuvering lane and adjacent channel bank. The criteria and elements used in determining channel width needed to accommodate existing and expected vessels transiting the waterway are presented in Exhibit 2. The criteria include consideration of the following factors:

1. Size and speed of design vessels
2. Density of vessel traffic
3. Depth of channel
4. Current, velocity and direction
5. Vessel controllability on and off channel centerline
6. Pilot experience and capability
7. Channel uniformity
8. Tugboat assistance

The existing channel, with the exception of the bends, is 400 feet wide. The pilots and users of the harbor have verified the adequacy of the width.

Area 3 Channel. One area of special concern is the bend in the vicinity of Goat Island. Previous work in the channel has widened the

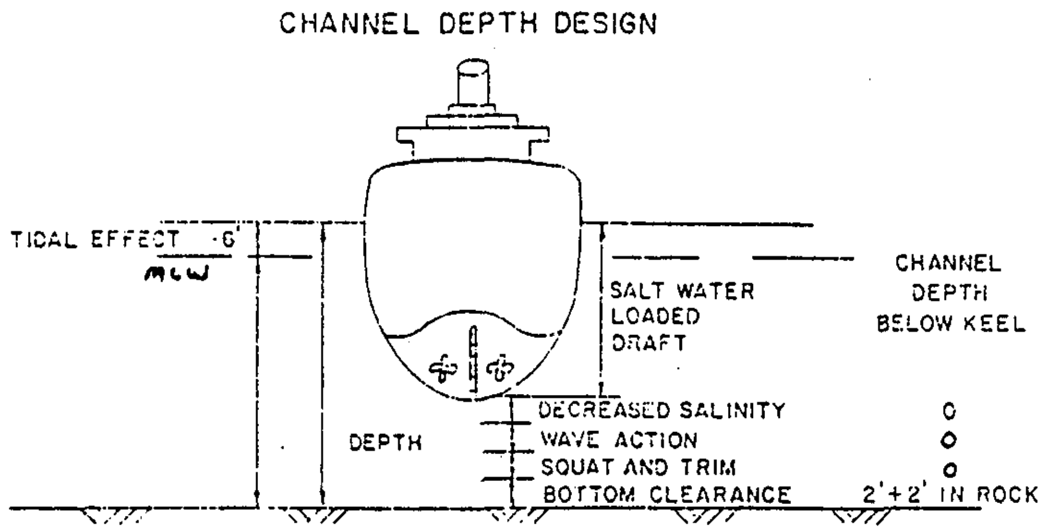

Exhibit 1

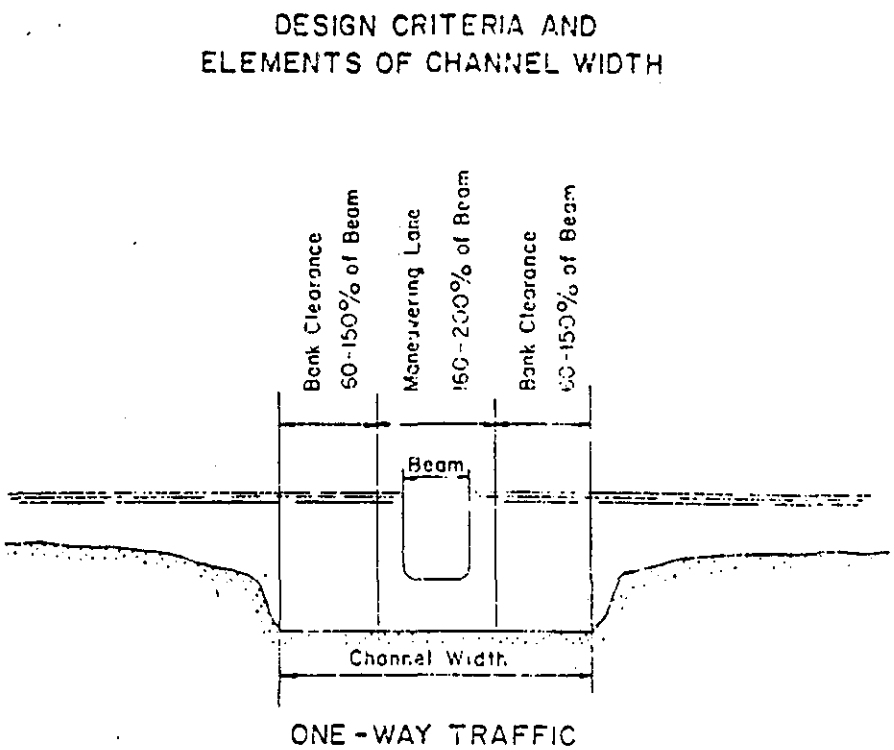

Exhibit 2

bend to a maximum of 800 feet, which appears adequate. However, vessels coming into port must begin their turns in the channel about 1,000 feet prior to any point of widening. Therefore, the channel should properly be widened to accomodate the beginning of the turning maneuver. A width of 550 feet would be adequate based on a manuevering lane of 300 percent of the beam and clearance lanes of 150 percent of the beam. The pilots and users have indicated that the width of 550 feet for an additional length of 1,000 feet would help in making their turns.

Area 1 Turning Basin and Channel. Area 1, which is located between the two lift bridges poses two difficulties to navigation. The first is the inadequate width of the 600' channel. The present width is inadequate because there is not enough room to turn a large vessel between the two bridges. The bends, bridges and current in this area require emergency turning capability in the event of mechanical malfunction or emergency. The proposed emergency maneuvering area is approximately 150 percent of the design vessel length.

The second is the bend at Badgers Island which is currently limited to a 600-foot width. At this location where ships must pass through the lift ridges and navigate around the rock bend, 500 percent of the beam (455 feet) is considered necessary for the maneuvering lane and 150 percent for bank clearance on either side or 135 feet. This provides a total width of 725 feet.

B. COST ESTIMATES

RECOMMENDED PLAN

This plan centers around improvements to the navigation channel at Areas 1 and 3 as shown on Plate 1 of the main report. The proposed project features are described below.

1. Widen the existing channel which is located between the vertical lift bridges from its current 600-foot width to 1,000 foot width. (Area 1)

2. Widen, by 100 feet, the northern limit of the channel at the bend adjacent to Badgers Island. (Area 1)

3. Widen, by 150 feet, the southern portion of the channel at the bend in the vicinity of Goat Island from its current width of 400 feet to 550 feet. (Area 3)

This plan would require the removal and disposal of 320,000 cubic yards of ordinary overburden material and 193,000 cubic yards of rock. The overburden material is primarily composed of clean sands and gravel. A bucket or clamshell dredge would be used to remove this material. The removal of ledge rock and boulders would require drilling and blasting. It is contemplated that the material would be transported to the Foul Area for disposal.

ESTIMATED PROJECT INVESTMENT

RECOMMENDED PLAN

October 1985 Price Level

Cost Estimate With Disposal at the Foul Area

Dredging overburden and glacial till 320,000 cy @ $12.40/cy	=	$ 3,968,000
Removal Ledge Rock 193,000 cy @ $54.70/cy	=	10,557,100
Subtotal	=	$ 14,525,100
Contingencies 15%	=	2,174,900
Total Dredging Cost	=	$ 16,700,000
Engineering and Design	=	370,000
Supervision and Administration	=	830,000
Total Construction Cost		$ 17,900,000
Aids to Navigation		20,000
Total Investment Cost		$ 17,920,000

Annual Charges

Interest and Amortization (8 5/8%, 50 years)	$ 1,660,000
Annual Maintenance Aids to Navigation	$ 1,000
Annual Maintenance (dredging)	Minor
TOTAL ANNUAL COST	$ 1,661,000

APPENDIX G

PERTINENT CORRESPONDENCE

APPENDIX G
PERTINENT CORRESPONDENCE

Table of Contents

STATE OF MAINE

EXECUTIVE DEPARTMENT

STATE PLANNING OFFICE

JOSEPH E. BRENNAN
GOVERNOR

RICHARD E. BARRINGER
DIRECTOR

February 2, 1984

Colonel Carl B. Sciple
Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Sciple,

This letter is to notify you of our concurrence with your determination that the proposed improvement dredging in the Piscataqua River is consistent with Maine's Coastal Program.

The Maine Board of Environmental Protection issued a Water Quality Certification and consistency concurrence with the Wetlands law for this project on January 11, 1984. A copy of the Board's order is enclosed with this letter.

With best wishes.

Sincerely,

Dick

Richard E. Barringer

REB:nv

enclosure

184 STATE STREET, STATE HOUSE STATION 38, AUGUSTA, MAINE 04333 TEL. (207) 289-3261 or 3154

DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE HOUSE STATION 17 AUGUSTA, MAINE 04333

BOARD ORDER

IN THE MATTER OF

U.S. ARMY CORPS OF ENGINEERS	) Federal Consistency Review & Concurrence
Kittery, Maine, York County	)
DREDGING, PISCATAQUA RIVER	) And Water Quality Certificatio
#03-9164-31130	) FINDINGS OF FACT AND ORDER

After reviewing the project file which includes an application for a consistency determination under 38 M.R.S.A., Sec. 471-478, **Alteration of** Coastal Wetlands Law and an application for a Water Quality **Certification**, under Title IV, Section 401 of the Federal Water Pollution Control Act, the staff summary and other related materials on file with regard to the above noted project, the Board finds the following facts:

1. The Maine Coastal Zone Management Program was approved on September 30, 1978 by the Federal Office of Coastal Zone Management. Under Sec. 307 of the Coastal Zone Management Act, as amended, federal activities which affect land or water resources in the coastal zone must be undertaken in a manner consistent, to the maximum extent practicable, with the requirements of Maine's approved Coastal Zone Management Program.

2. In a letter and application dated November 18, 1983, Colonel Carl B. Sciple of the New England Division Corps of Engineers has requested a consistency determination pursuant to Maine's Coastal Zone Plan for navigation improvements in two areas of the Piscataqua River in Kittery, Maine and Portsmouth, New Hampshire.

3. This project must also receive Water Quality Certification pursuant to Section 401 of the Federal Water Pollution Control Act prior to beginning work.

4. The proposed improvement project consists of removal of unconsolidated materials in the maneuvering area between the two vertical lift bridges. This area is shown as Area #1 on plan of Portsmouth Harbor & Piscataqua River by the New England Division, Corps of Engineers dated January 1982.

5. Dredging in Area #1 will result in widening the 35 foot deep navigation channel from 600 feet to 1000 feet.

6. A second portion of the proposed improvement project consists of removal of ledge and unconsolidated materials in the vicinity of Henderson Point on Seavey Island, Kittery, Maine and Goat Island, New Hampshire. This area is shown as Area #3 on plan of Portsmouth Harbor & Piscataqua River by the New England Division, Corps of Engineers dated January 1982.

7. Dredging in Area #3 will result in widening the southern limit of the 35 foot deep navigation channel from 400 feet to 550 feet.

8. Dredging in Areas #1 and #3 noted above, will result in the removal of 228,000 cubic yards of sand and gravel and 305,000 cubic yards of rock. Testing of the sand and gravel has shown these sediments to be uncontaminated.

9. Dredging will be done with a bucket or clamshell dredge. Rock removal will require drilling and blasting. The Corps proposes a continuous 16 month work period to complete the project.

10. Disposal of dredged material is to be at the New Hampshire State Port Authority site in Portsmouth, New Hampshire (Cutts Cove). Disposal at this site would result in the elimination of approximately 15 acres of intertidal and subtidal aquatic habitat. The Cutts Cove disposal site would involve the filling of 10 acres of mud flats including 0.6 acres of salt marsh.

11. The Piscataqua River supports the following fish species: striped bass, mackeral, flounder, Atlantic salmon, rainbow smelt, shad and alewives. Lobster and crab are numerous, especially in the harbor entrance and lower portions of the river.

12. The Corps of Engineers has in its Feasibility Report listed the expected impacts of blasting. Impacts range from damage to individual fish to large fish kills. While there are some precautionary measures such as warning charges and sceduling blasting to avoid peak periods of fish migration and spawning that can reduce fish and invertebrate mortality, the Corps has not specifically proposed any of these measures.

13. The Corps predicts that impacts on water quality from the dredging project will be short term. These water quality impacts include: increased turbidity; the temporary disturbance and release to the water column of nutrients; some heavy metals, some oil and grease; and the minor release of hydrogen sulfide odors. Temporary dissolved oxygen reduction could occur in the surrounding waters druing dredging due to suspension of organic detritus, fecal pellets and other natural organic compounds. The Corps expects these water quality impacts to be short term because of high current flow and good mixing in the project area.

14. Because the two areas to be dredged are located to the side of the main channel, the Corps does not expect that the water quality impacts would inhibit fish movement.

BASED on the above findings of fact, the Department concludes that the proposed activity will satisfy the requirements of Title 38, M.R.S.A., Section 474 and Section 401 of the Federal Water Pollution Control act for the issuance of an Alteration of Coastal Wetlands Permit and a Water Quality Certification, in that:

A. The project will not unreasonably interfere with existing recreational and navigation uses.

B. The project will not cause unreasonable soil erosion.

U.S. ARMY CORPS OF ENGINEERS) Federal Consistency Review &
Kittery, Maine, York County) Concurrence
DREDGING, PISCATAQUA RIVER) And Water Quality Certification
#03-9164-31130) FINDINGS OF FACT AND ORDER

C. The project will not unreasonably harm wildlife or freshwater, estuarine, or marine fisheries provided lobsters and finfish are removed from immediate areas of dredging and blasting and provided a blasting schedule which reduces blasting during anadromous fish runs is developed and implemented.

D. The project will not unreasonably interfere with the natural flow of any waters.

E. The project will not lower the quality of any waters, and will not violate applicable Water Quality Standards in that the affects as noted in Finding #13 noted above will be temporary.

THEREFORE, the Board APPROVES the application of the U.S. ARMY CORPS OF ENGINEERS for a Consistency Determination and Water Quality Certification to dredge 228,000 cubic yards of sand and gravel and 305,000 cubic yards of rock from areas noted as Area #1 and Area #3 on plan of Portsmouth Harbor & Piscataqua River by the New England Division, Corps of Engineers dated January 1982, subject to the following conditions:

1. The Standard Conditions of Approval, a copy attached.

2. The Corps of Engineers shall survey the areas in which dredging and blasting is to occur. This survey shall be done immediately prior to dredging or blasting. Should lobsters be found in a ratio of greater than one lobster per square meter, the lobsters shall be removed from the area prior to dredging or blasting.

3. Within 365 days of this Order or prior to dredging, the Corps of Engineers shall submit a plan indicating how blasting affects on finfish will be minimized. This plan shall as a minimum contain a schedule of blasting during anadromous fish runs. This plan shall also provide measures for moving finfish out of the immediate blast area. This plan must receive approval of the Commissioner prior to dredging.

DONE AND DATED AT AUGUSTA, MAINE, THIS 13TH DAY OF JANUARY, 1984.

BOARD OF ENVIRONMENTAL PROTECTION

BY: ______________________
HENRY E. WARREN, Chairman

PLEASE NOTE ATTACHED SHEET FOR APPEAL PROCEDURES....

OFFICE OF STATE PLANNING
STATE OF NEW HAMPSHIRE
2½ BEACON STREET — CONCORD 03301
TELEPHONE 603-271-2155

February 3, 1984

Colonel Carl B. Sciple
Division Engineer, Department of the Army
Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

ATTENTION: Planning Division
Impact Analysis Branch

Dear Colonel Sciple:

The federal consistency review for the dredging portion of the Portsmouth Harbor and Piscataqua River Navigation Improvement Project has been completed.

The New Hampshire Coastal Program (NHCP), in consultation with state, regional, and local agencies, concurs with your assessment that the proposal is consistent with the policies of the NHCP. The Wetlands Board, as part of its approval, recommended that work at the dredge site opposite Seavey Island be conducted during the period from December to March.

A meeting was held at the Office of State Planning on 18 January 1984 to review the project and provide an opportunity for state agencies with responsibilities in the harbor area to discuss their concerns with staff from the Corps. Three major state areas of concern were raised at the meeting and were summarized in a letter on 24 January 1984 to Paul E. Pronovost, Chief Impact Analysis Branch. A copy of this letter is enclosed for your files.

The first two concerns - fishery protection and recreational and small commercial boating - are reflected in the Wetlands Board recommendation on timing. It is our understanding that the Corps will submit a letter to this office stating that it is feasible to perform the blasting work at the Seavey Island site between December and March and that every effort will be made to accomplish the work during this time period.

The third area of concern - water quality considerations - has been reviewed by the Water Supply and Pollution Control Commission. I enclose, for your information, a copy of their statement of concurrence.

Review of this project has provided an opportunity to establish contact and communication between the New Hampshire Coastal Program and Corps of Engineers personnel. I appreciate the efforts of your staff and their willingness to provide requested information and attend meetings, here in New Hampshire, that have allowed detailed and valuable discussions of the proposal.

Sincerely,

Marcia O. Keller

Marcia O. Keller
Federal Consistency Coordinator

MOK/slj

Enclosures

MAINE HISTORIC PRESERVATION COMMISSION
55 Capitol Street
Augusta, Maine 04333

Earle G. Shettleworth, Jr.
Director

Telephone:
207-289-2133

June 18, 1984

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Ignazio:

In regard to your proposed dredging of parts of the Piscataqua River in Maine and New Hampshire, I have reviewed "Underwater Testing, Portsmouth Harbor" by Michael Roberts and Warren Riess. I find this report to be excellent.

Given that both remote sensing and visual inspection conclusively ruled out the presence of significant underwater archaeological reosurces, I find that the proposed dredging will have no effect upon any structure or site of historic, architectural, or archaeological significance as defined by the National Historic Preservation Act of 1966.

If I can be of further assistance concerning this matter, please do not hesitate to let me know.

Sincerely,

Earle G. Shettleworth, Jr.
State Historic Preservation Officer

cc: Dr. Robert L. Bradley
Maine Historic Preservation Commission

EGS/slm

January 2, 1985

Engineering Division

Mr. Henry E. Warren
Commissioner
Maine Department of Environmental Protection
State House, Station 17
Augusta, Maine 04333

Dear Mr. Warren:

I am writing in regard to the proposed improvement dredging project for Portsmouth Harbor and the Piscataqua River. This project is currently in the final design stage with an earliest construction date estimated to be the Fall of 1986 contingent upon authorization and funding by Congress. I understand that the State of Maine has expressed concern with the possible environmental impacts the project could have on lobsters in the area and the effects from blasting on anadromous fish during spawning runs.

With respect to the lobster question we are currently making plans to conduct a field lobster survey to determine the population density in the proposed project area. This initial survey would serve to determine the lobster densities extant in the project area. The survey itself would consist of a one day effort taking six-two-meter wide transects (three in each dredge area) by biologist divers. If lobsters are found in densities equal to or less than one/square meter then no further action would occur. If densities prove to be greater than one/square meter we would conduct further investigations.

In addition to the lobster study, we are prepared to undertake an anadromous fish monitoring program during construction in order to minimize impacts to the anadromous fish populations within the river. A biological technician will make observations during all blasting operations as described in Attachment A. The monitoring team itself will include biologists from the States of Maine and New Hampshire, the Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the Corps of Engineers who will provide advice and make recommendations on timing of blasting operations relative to anadromous fish runs, review observation data, and assist in undertaking fish avoidance measures if needed.

We would like to have a meeting sometime in January 1985, if possible, to discuss the following:

a) Lobster survey methodologies

b) Anadromous fish monitoring team members and responsibilities

c) State's assistance with lobster survey and monitoring activities.

Your staff will be contacted by Mr. Russ Bellmer to coordinate time and date of the meeting. If you have any additional questions, please contact him at (617) 647-8142.

Sincerely,

Richard D. Reardon
Chief, Engineering Division

Attachment

Copies Furnished:
Dr. Richard Langton, Director
Bureau of Marine Sciences
Fisheries Research Station
Maine Department of Marine Resources (DMR)
West Boothbay Harbor, Maine 04575

Mr. Brad Sterl
Maine Department of Marine Resources
Augusta, Maine 04333

Mr. Peter Piattoni
NH Coastal Zone Management
Office of State Planning
2 1/2 Beacon Street
Concord, NH 03301

ATTACHMENT A

The anadromous fish monitoring would consist of a biological technician monitoring (individual counts per unit time) selected species during pre-determined times of blasting activities, writing up field data, and coordinating with members of the multi-agency team.

The multi-agency team would consist of biologists from the State of Maine, State of New Hampshire, U. S. Fish and Wildlife Service, Environmental Protection Agency, and Corps of Engineers. This team would determine times of monitoring and select species to be monitored from the following: _Alosa sapidissima_ (_shad_), O_smerus mordax_ (_smelt_), P_omolobus aestivalis_ (blueback herring), P_omolobus pseudoharengus_ (alewives), O_ncorhynchus kisutch_ (silver salmon), and _Salmo salar_ (Atlantic salmon). In addition, this team would make recommendations to the project manager of measures to reduce potential impacts, if necessary.

August 8, 1985

NEDPL

Honorable John H. Sununu
Governor of the State of New Hampshire
Concord, New Hampshire 03301

Dear Governor Sununu:

The Portsmouth Harbor and Piscataqua River project is one of a number that the Corps of Engineers has under consideration as a potential new construction start in Fiscal Year 1987. However, as you probably are aware, efforts to control the budget deficits have limited the amount of Federal funds made available for such programs as development of water resources. Also, this Administration and Congress believe that a higher degree of non-Federal cost sharing and financing of water projects is both desirable and necessary to put the water program on a sound basis.

To stretch the funds that may be made available for new construction starts, the Corps is seeking to work with those sponsors who are willing to increase their share of the construction and financing costs and jointly move ahead in implementing their project. These cost sharing and financing arrangements would be consistent with S. 366, as reported out by the Senate Environment and Public Works Committee on July 16, 1985, which reflects a compromise previously reached between the Administration and the Senate majority leadership. We would like to discuss with you the possibility of proceeding with the Portsmouth Harbor and Piscataqua River project under these arrangements. To that end, I would like to arrange a meeting with you to discuss our program and what would be involved in funding the construction of your project.

Any project that we may include in the Fiscal Year 1987 budget is subject to review and approval by both the OMB and the Congress. However, I might point out that the House of Representatives has under consideration a bill which also will increase the non-Federal share of project funding; this bill needs to be reconciled with the Administration/Senate majority leadership bill. Any contractual agreement based on the above proposal would allow modification of the agreement to reflect the provisions of any legislation subsequently enacted into law. Of course, we fully understand that you will want to weigh the advantages and disadvantages in your own situation, as well as all the options open to you. Whether or not you wish to proceed with us is entirely your option.

In any case, I want to offer what I believe is a realistic program for moving ahead with good water projects in Fiscal Year 1987. I hope you are interested and that I will hear from you soon. Since time is important if your project is to be a candidate for the Fiscal Year 1987 program now being developed for submission this summer, I suggest that we meet prior to August 23, 1985. Please fee free to call me at 617-647-8222.

Sincerely,

Edward D. Hammond
LTC, Corps of Engineers
Acting Division Engineer

Copies Furnished:

David C. Scott
Acting Director
Office of State Planning
2-1/2 Beacon Street
Concord, New Hampshire 03301

George E. Smith
Director
New Hampshire Port Authority
555 Market Street
Portsmouth, NH 03801

JOHN H. SUNUNU
GOVERNOR

STATE OF NEW HAMPSHIRE

OFFICE OF THE GOVERNOR

STATE HOUSE · CONCORD, NEW HAMPSHIRE 03301

September 6, 1985

Lt. Colonel Edward D. Hammond
Deputy Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Dear Colonel Hammond:

Reference is made to discussions on August 26, 1985, with you and members of my staff at the State Planning Office regarding the construction of the Portsmouth Harbor and Piscataqua River project.

This letter constitutes an expression of intent by the State of New Hampshire to cooperate with the Federal Government in initiating construction of the Portsmouth Harbor Project in Government Fiscal year 1987.

To facilitate construction of the Portsmouth Harbor navigation project, the State of New Hampshire will seek commitments to the following items of local cooperation:

a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for implementation and maintenance of the project and for aids to navigation upon the request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and later disposal of dredged material, and including necessary retaining dikes, bulkheads, and embankments therefor, or the costs of such retaining works;

b. Hold and save the United States free from damages due to implementation and maintenance of the project, not including damages due to fault or negligence of the United States or its contractors;

c. Provide and maintain without cost to the United States adequate terminal and transfer facilities open to all on equal terms;

d. Provide and maintain without cost to the United States adequate depths in berthing areas and local access channels serving the terminals;

e. Accomplish without cost to the United States all alterations and relocations of transportation facilities (excluding railroads, combined highway and railroad and publicly owned highway bridges and approaches thereto), storm drains, sewer outfalls, utilities, and other structures and improvements made necessary by the project;

f. Prohibit the erection of any structure within a distance to be determined by the Chief of Engineers from the bottom edge of the proposed channel and turning basin; and

g. Subject to final approval by state and/or local interests, and subject to completion of written agreements, provide a cash contribution based on the final project cost allocated to any special local benefits derived from dredged material disposal.

It is understood that the items of local cooperation as previously stated are a non-Federal responsibility and that the State of New Hampshire will bear the full costs thereof, regardless of any cost sharing percentages specified below.

In addition, the State of New Hampshire proposes to pursue, following executive and legislative concurrence, such funds during the term of construction as are necessary to meet the non-Federal requirements which are estimated as follows:

Estimated Cost of Navigation Project		$23,500,000
Federal Share	65%	$15,275,000
Non-Federal Share		
Cash	25%	$ 5,875,000
Repayment (30 years)	10%	$ 2,350,000

It is understood that these estimates of cost are preliminary and that final costs will depend on the actual costs of construction. Further, it is understood that the non-Federal share is subject to revision based on the enactment of cost sharing legislation now pending before Congress. In particular, it is noted that the Senate version of cost sharing legislation (S1567, Section 603(b)) contains provisions which authorize the Secretary to reduce the non-Federal share if a project provides benefits directly related to national defense requirements of the United States, as is the case in Portsmouth Harbor.

The project to be constructed is that generally described in the Chief of Engineers' Report dated February 25, 1985. Attached as Exhibit A, is a schedule of non-Federal expenditures for the cash contribution portion of the non-Federal requirement through fiscal year 1989. The schedule is based on a $23,500,000 estimate of total projects costs, which includes an allowance for inflation through the construction period.

Prior to construction, the State of New Hampshire, subject to State and local approvals, will enter into a binding written agreement with appropriate representatives of the Corps of Engineers which addresses project construction and satifies the requirements of Section 221 of Public Law 91-611. (Attached as Exhibit B is an assessment of the State's ability to pay the non-Federal portion of costs for the project).

It is further understood that if this letter of intent is acceptable to the Assistant Secretary of the Army (Civil Works), he will recommend to the Office of Management and Budget that an appropriate request for funds to support the Portsmouth Harbor and Piscataqua River project construction be included in the President's budget for Fiscal Year 1987. As previously recognized, if legislation is enacted which changes cost sharing and financing for the Portsmouth Harbor project, such cost sharing and financing provisions will supersede the proposed financial arrangements contained herein.

Sincerely,

John H. Sununu
Governor

JHS/DCN:am

Attachments

EXHIBIT A

PORTSMOUTH HARBOR AND PISCATAQUA RIVER PROJECT

Schedule of Estimated Federal and Non-Federal Expenditures

($000)

	FY 1987	FY 1988	FY 1989	TOTAL
Federal	$2,900	$12,300	$2,425	$17,625
Non-Federal	1,000	4,000	775	5,875
ANNUAL TOTAL	3,900	16,400	3,200	23,500

EXHIBIT B

PORTSMOUTH HARBOR AND PISCATAQUA RIVER PROJECT

It is likely that funds for the non-Federal share will be derived from the issuance of bonds backed by the full faith and credit of the State of New Hampshire. The State has no constitutional limitation on its power to issue obligations or incur indebtedness and there is no constitutional requirement that a referendum be held prior to the incurrence of any such debt. The authorization and issuance of State debt, including the purpose, amount and nature thereof, the method and manner of the incurrence of such debt, the maturity and manner of repayment thereof, and security therefor, are wholly statutory.

Therefore, it is considered well within the ability of the State to pay the order-of-magnitude non-Federal portion of costs of the project through the issuance of bonds consistent with other State priorities and fiscal prudence as determined by the Governor and Council and the General Court.